Science Education

Talent Recruitment and Public Understanding

Edited by
Peter Csermely
Leon Lederman

IOS Press
Ohmsha

NATO Science Series

Series V: Science and Technology Policy – Vol. 38

SCIENCE EDUCATION

NATO Science Series

A series presenting the results of scientific meetings supported under the NATO Science Programme.

The series is published by IOS Press and Kluwer Academic Publishers in conjunction with the NATO Scientific Affairs Division.

Sub-Series

I.	Life and Behavioural Sciences	IOS Press
II.	Mathematics, Physics and Chemistry	Kluwer Academic Publishers
III.	Computer and Systems Sciences	IOS Press
IV.	Earth and Environmental Sciences	Kluwer Academic Publishers
V.	Science and Technology Policy	IOS Press

The NATO Science Series continues the series of books published formerly as the NATO ASI Series.

The NATO Science Programme offers support for collaboration in civil science between scientists of countries of the Euro-Atlantic Partnership Council. The types of scientific meeting generally supported are "Advanced Study Institutes" and "Advanced Research Workshops", although other types of meeting are supported from time to time. The NATO Science Series collects together the results of these meetings. The meetings are co-organized by scientists from NATO countries and scientists from NATO's Partner countries – countries of the CIS and Central and Eastern Europe.

Advanced Study Institutes are high-level tutorial courses offering in-depth study of latest advances in a field.
Advanced Research Workshops are expert meetings aimed at critical assessment of a field, and identification of directions for future action.

As a consequence of the restructuring of the NATO Science Programme in 1999, the NATO Science Series has been re-organized and there are currently five sub-series as noted above. Please consult the following web sites for information on previous volumes published in the series, as well as details of earlier sub-series:

http://www.nato.int/science
http://www.wkap.nl
http://www.iospress.nl
http://www.wtv-books.de/nato_pco.htm

Series V: Science and Technology Policy - Vol. 38 ISSN: 1387-6708

Science Education

Talent Recruitment and Public Understanding

Edited by

Peter Csermely

Semmelweis University, Budapest, Hungary

and

Leon Lederman

Illinois Mathematics and Science Academy, Aurora, USA

IOS Press

Ohmsha

Amsterdam • Berlin • Oxford • Tokyo • Washington, DC

Published in cooperation with NATO Scientific Affairs Division

Proceedings of the NATO Advanced Research Workshop on
Science Education: Talent Recruitment and Public Understanding
19–21 April 2002
Budapest, Hungary

ISBN 1 58603 308 5 (IOS Press)
ISBN 4 274 90565 9 C3040 (Ohmsha)
Library of Congress Control Number: 2002115739

Publisher
IOS Press
Nieuwe Hemweg 6B
1013 BG Amsterdam
Netherlands
fax: +31 20 620 3419
e-mail: order@iospress.nl

Distributor in the UK and Ireland
IOS Press/Lavis Marketing
73 Lime Walk
Headington
Oxford OX3 7AD
England
fax: +44 1865 75 0079

Distributor in the USA and Canada
IOS Press, Inc.
5795-G Burke Centre Parkway
Burke, VA 22015
USA
fax: +1 703 323 3668
e-mail: iosbooks@iospress.com

Distributor in Germany, Austria and Switzerland
IOS Press/LSL.de
Gerichtsweg 28
D-04103 Leipzig
Germany
fax: +49 341 995 4255

Distributor in Japan
Ohmsha, Ltd.
3-1 Kanda Nishiki-cho
Chiyoda-ku, Tokyo 101-8460
Japan
fax: +81 3 3233 2426

PRINTED IN THE NETHERLANDS

Contents

Session I. Introductory Session – Opening Addresses
Péter Csermely, Gábor Szabó, Gregorio Medrano-Asensio, Ragnhild Sohlberg, Diana Malpede, Benito Righetti and Leon Lederman 1

Session II. Gifted Children: Recognition, Problems, Coping

Scientific Thinking in Gifted Children, *Joan Freeman* 17
Talent, Science and Education: How do we Cope with Uncertainty and Ambiguities?, *Katya Stoycheva* 31
Developing Programs for Science-minded Children at the Age of 7–12, *Maria Herskovits* 44
Creative Imagination in Science and Science Education, *Wiesława Limont* 53
Science Education: Early Recruitment as a Necessity and Creative Problem Solving as Didactical Option, *Ida Fleiss* 60
The Implementation of the Talent Search Concept in Spain, *Javier Tourón and Marta Reyero* 63
Talent Development and Cultural Diversity, *David Brandon, Muli Dotan, Orit Zaslavski and Roza Leikin* 77
Future Scientists and School Attendance, *Eva Vondrakova* 89

Session III. Extracurricular Science Education

The Ashoka Innovative Learning Initiative, *Laura Ax and Barbara Erös* 99
Education Program for Environment Safety, Quality and Social Responsibility: The Case of Transpetro S A Company and Surrounding Communities, *Edison Durval Ramos Carvalho, Samuel Macarini and Lucilene Anciguer* 108
Talent Development in Residential Summer Programmes, *Harald Wagner* 117
Science Education Programs for Middle School and High School Students Sponsored by the Howard Hughes Medical Institute, *Jill Conley* 129
Mentor, Merlin, Muse: Inspiring Poets and Scientists. The Illinois Mathematics and Science Academy Program, *Peggy Connolly, Eric Szczesniak and Lina Nayak* 138
Using New Technologies in Physics Teaching to Promote Students' Involvement, *Lidia Borghi, Anna de Ambrosis and Paolo Mascheretti* 147
What do Gifted Children Think about the Quality in Education, *Jasna Cvetković Lay* 159

Session IV. Scientific Research Training

Howard Hughes Medical Institute Sponsored Student and Teacher Internships at the National Institutes of Health in Bethesda, Maryland, USA, *Sandra R. Shmookler* 169

Mentoring Students and Teachers for High-stakes Science Competitions, *Bonnie Kaiser* 178
The Role of History in Training. Canalisation of High School Students to Scientific Research, *Ayse Gulcin Kucukkaya* 185
Six Years of Scientific Research Training in Hungary. Progress, Plans, Problems, *Péter Csermely, Zoltán Borsodi, Tamás Korcsmáros and Bálint Pató* 191
Visnjan Educational Project: Introduction to Science Through Astronomy, *Korado Korlevic* 199
Specialities of Gifted Children Education in Post-Soviet Countries, *Ruslan Mariychuk and Vasil Petrus* 211
New Strategic Orientation of the Treatment of Gifted and Talented Students in the Republic of Macedonia, *Ljupco Kevereski* 218
System of Work with Gifted Children in Gymnasia No. 5, Minsk, Belarus, *Eleanora Kakareka and Margarita Kotlyarova* 222
Care for Future Scientists within the Education System in Slovakia, *Jolana Laznibatová* 227

Session V. Social Environment of Science Education

Young Talents and EUREKA, *Otto F. Joklik* 233
Virtual Technology Development and Transfer – Hall of Talents, *Janewit Pitayataratorn* 237
The International Forum of Young Scientists – A UNESCO Initiative, *Diana Malpede* 243
The Impact of Public Policy and Private Initiative in Promoting Gifted and/or Talented People, *Mihai Jigău* 251
From Jefferson to Feynman: US Aspirations for Science and Technology Education, *Rodney W. Nichols* 259
Science Magazines in North America, *Jane Aspell* 278
Opportunities for Realization of Potential in Science and Technology in Gifted Programs in Israel, *Shlomit Rachmel and Rachel Zorman* 283
Adolescent Pathways to Eminence in Science: Lessons from the Music Conservatory, *Rena F. Subotnik* 295

Concluding Remarks and Perspectives, *Péter Csermely* 305

Author Index 307

Session I

Introductory Session – Opening Addresses

This page intentionally left blank

Peter Csermely
Hungarian Young Researchers Association

It is my special pleasure to welcome all the participants of this NATO Advanced Research Workshop with UNESCO participation.This workshop was originated one and a half years ago. At that time we had a meeting in Dresden co-organized by NATO, Nature and the Volkswagen Foundation. The meeting summarized the progress of the first ten years in helping Eastern European science after the political changes in 1989-1990. One of the conclusions of the Dresden meeting was that the participation of young scientists in science is an area where we have to do a lot more.

The 1988 Nobel Laureate of physics, Leon Lederman, whom I met a few years ago during the World Conference on Science in Budapest helped us a lot to organize this meeting. He apologizes but unfortunately he's unable to be present at the meeting. He sent us a greeting, which will be read a few minutes later. Let me introduce and greet the members of the "presidency":

It is my special pleasure to greet Gábor Szabó, who is the Under Secretary of State for Research and Development representing the minister of education, József Pálinkás. As you might know we will have elections the day after tomorrow. Life of the ministers is always busy but it is perhaps even busier at this time. Of course we understand that Mr. Pálinkás has many-many duties and it is a true pleasure that Mr. Szabó could come to this meeting.

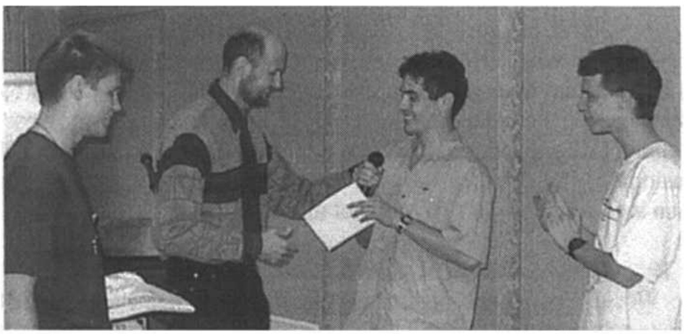
It is my honor to welcome Ragnhild Sohlberg. She is representing the ultimate most sponsoring organization of this meeting, NATO.

It is my great pleasure to welcome Gregorio Medrano-Asensio, who is representing the European Union and actually representing Philippe Busquin, Commissioner of the European Union, who is one of the patrons of the meeting besides minister Pálinkás and Ferenc Mádl, the president of Hungary.

It is my special pleasure to welcome Diana Malpede from the UNESCO. UNESCO is co-sponsoring the meeting and I think Diana will have a few minutes to describe you why it is so important for UNESCO in general and in special to participate in this meeting.

As you could see there are many-many sponsoring organizations for our movement in Hungary and this meeting in special (like the Béres Foundation, EGIS Co., Embassy of the Italian Republic, Gedeon Richter Co., Hungarian Association for Innovation, Hungarian Patent Office, Industrial R&D Foundation, Ministry of Education, Ministry of Environmental Protection, "Műszaki" Publishers Budapest, NATO, Program for Children and Youth, UNESCO, etc.). Out of them let me single up the Embassy of the Italian Republic and actually the Foreign Ministry of the Italian Republic, which is represented by Benito Rhigetti, the scientific attaché of the embassy, who will also give a short introduction.

Finally I would like to thank to my colleagues, who helped me to organize this meeting: I have already mentioned the Co-director, Leon Lederman. It was the young team of Mr. Balint Pato, Tamas Korcsmaros, Zoltan Borsodi and Ms. Livia Meszaros who helped a lot in the correspondence and organization. I have to single out Mr. Pato, whom you were and will be in touch, as he undertook many of the technical parts of the editorial work on the proceedings volume of this meeting.



Last, but not least the excellent technical help of Ms. Edit Vadkerty and Reka Kancler is greatly acknowledged. Without their organization most of us would not sit here today.

So it is time to give Mr. Szabó the floor to open the meeting!

Gábor SZABÓ
Under Secretary of State for Research and Development,
Ministry of Education, Hungary

Good afternoon ladies and gentlemen! My name is Gábor Szabó and I am representing Mr. József Pálinkás, the Minister of Education of Hungary. From time to time I have to substitute my minister at different occasions, which is not always a full pleasure. This is an exceptional occasion. I was really happy to come here, because it is also an exception that my two identities can fully and simultaneously identify with the issue being discussed. My identity as a university professor, – actually my real identity – and my temporal identity as the Under Secretary of State for Research and Development.

I believe that this is a very important occasion and it was perceived by Mr. Pálinkás as such. I really can only thank for your invitation. And what dr. Csermely has just mentioned, is true. Yesterday we had a briefing with Mr. Pálinkás: he asked me to make notes for his speech today – that *was* yesterday eleven o'clock. At four o'clock he told me: 'better you tell it yourself..." – Life is very difficult for politicians these days when election is underway in Hungary.

Coming back to the issue, which I really think is important: the involvement of young talents in science. If you asked me to define what talent is, I have to disappoint you, I am absolutely unable to do so. For me it is just as an elusive concept as beauty is. If I had to define beauty I do not think that I would be able to come up with any sensible idea but I can tell you in a second when I see beauty. From my own experience as a professor I can tell you that this is exactly the same with talent. I cannot define talent but when I meet a talented student, perhaps not in a second but in a couple of weeks I can really judge it.

Of course this makes issues more complicated... you don't even know what you are dealing with but you have to give it the best possible treatment because it is, whether or not we can define it, one of the ultimate treasures of humankind. One has to be very careful that not a single piece of it gets lost! Of course there are some aspects of all educational and administrative systems, which sometimes loose or even misuse talent because it could be very inconvenient. Talent is unusual, and unlike a screw in a big machine it is not always well fit. But we have to be aware of that, and as an educator one really has to make sure that this very natural tendency does not take over and talents are not lost by any means.

Dealing with talented people is also very important from a very selfish point of view. I don't think that there are too many in this room I had to convince that humankind is facing global problems. This is, of course, trivial. In my opinion, it is similarly trivial that there is no solution to these problems without a strong scientific aspect. There is no such an approach like "back to nature" or "the old Romans already knew". No, the Romans did not know how to deal with the greenhouse effect. We don't know what the solution is but one is clear, it will be global *and* scientific. For that selfish reason humankind badly needs the most talented minds in science. To solve the problems we are facing, to solve the problems that are really endangering the coming generations. So, it is a great future investment for societies to attract talented young people into scientific carriers.

This is not an easy job. I had the privilege to work as a professor in several countries including the USA and Germany. From my all experience I know that this is just as difficult in the USA and Germany as in Hungary. Attracting people towards scientific carriers is not easy, because these carriers could be very enjoyable as a human life but sometimes when you measure success by some material means – first of all by money – these are definitely not the best ones. Those who are able to do science are basically able to do any other human activity. So these guys could be very efficient in making money as well if they decided to do so. Thus, it is very important that a healthy balance is found. Growing up in a country where very important decisions concerning your own life were not fully in your own hand, taught me that no kind of societal pressure should be directly exerted upon young people. One has to be very careful not to overdo and not to force anybody to any direction. This is a very delicate issue and I believe that there is no simple good solution for this. On the other hand it is absolutely clear, that we have to deal with it. Fortunately, there is a growing awareness worldwide. I know that there are many initiatives – again – starting from the USA but the EU also has its own incentives to increase the awareness of science in the society.

In all this international collaboration plays a pivotal role. It is clear that no existing country can solve this problem alone. Therefore I'm very pleased to see you here. People who are professional workers of this field come together and try to exchange their experiences and knowledge. Knowledge is very important but the exchange of knowledge is even more important. This is a very unique thing, because if both of us have one dollar and if I give you mine and you give me yours, nothing happens, both of us have still one dollar. But if both of us have an idea and you give me yours and I give you mine then both of us have two ideas! This is a very important aspect of such gatherings. And as I understand from the discussions with Dr. Csermely before the session, this meeting is hopefully just the beginning of something, what I really appreciate. There will be a variety of events following this meeting: exchange of students, teachers, and also similar workshops. Hoping that this is really the beginning I don't think that there is anything left for me but to wish you success for this workshop, and all the coming events that you wish to organize.

Thank you very much for your attention!

Gregorio MEDRANO-ASENSIO
Head of the unit "Public Awareness of Science; young people and science"
General Directorate "Research"
European Commission

Dear Mr. Under Secretary of State, Professor Csermely, Ladies and Gentlemen, Young Participants! It is a pleasure for me and an honor as an officer of the European Commission to convey to you the best wishes and the greetings of our commissioner, Mr. Philippe Busquin, one of the patrons of this meeting. I have to underline that within the general frame of our commissioner's policy to stimulate the development of science and technology in Europe the role of young people in science is one of the most important things. Of course there are different levels: first as a general background the public understanding of science and technology and the interest of the citizens for science and technology. Without these nothing can be done. Afterwards the interest of young people and the development of their scientific and technological vocations are coming. It is said that in some European countries at least the number of young people undertaking university studies in the field of science and technology seems to decrease. Young people in some cases believe that science and technology are more difficult than other matters. So there is a perceived risk that the percentage of failures in secondary school and in university studies is greater in scientific matters than in others. Therefore it is not enough to stimulate young vocations, it is also fundamental to improve pedagogical methods to teach what science and technology really is.

Europe is very rich from a cultural point of view. We have a variety of national and regional cultures but the basement is common. This is a basement which we built along many centuries of collaboration and of confrontation also. The exchange of experiences and good practices is fundamental in our continent. From this point of view I think that our continent is the richest in the world. So communication is also very important between nations.

In Europe the percentage of scientific workers is lower than the corresponding number in the USA and in Japan. Nevertheless we "produce" every year a similar number of diplomas and more Ph.D.-s than the United States. So we have to explore where do those people go, because they don't appear in the world market, something happens with them. That may be a problem of the homogeneity of statistics or the problem of the definition of scientific research. To give you an example: there are more and more mathematicians and statistical physicists working in banks trying to understand the financial phenomena. Are they counted as researchers? I think that following the usual protocol, they are not. But this was just an example.

From the point of view of the big policy there are two master pillars in the European Union activities for science, technology and education. One is the European Research Area which was proposed by commissioner Busquin, and that will be fostered by the new framework program what will be adopted hopefully in a short of time. And in parallel goes the European Space for University Teaching, the so called: Bologna Process. Going down from this general panorama and just to describe some of the activities of the European Commission to attract young talents and to help their development I would like to begin with mentioning the European Contest for Young Researchers which is run by the European Commission since 1989 and organized every year in different country. For example in 1999 it took place in Thessaloniki, in 2000 in Amsterdam, in 2001 in Bergen. In 2002 in Vienna and in 2003 it will take place in Budapest – this will be the second time when an associated country will organize it, being Norway the first one.

The European Contest for Young Researchers is based on equivalent national competitions, which are organized every year in all members of the EU, and in the big majority of the associated states. In addition to them we count with the participation of Russia, Ukraine, Belarus and Georgia as European full right participants and we also accept the participation of students from competitions in the United States, Japan, South Korea and from 2002, from the People's Republic of China.

Now we have every year about 100 participants at this contest. That means that since 1989 we accumulated about 1000 participants. This means lots of good ideas and thoughts. One of our initiatives undertaking in the coming future will be a place to exchange experiences and ideas or to try to explore how and why they followed their scientific carrier or abandoned their work in this field.

Another activity is the so called Archimedes Prize. It is in its initial phase. It is a prize targeted to undergraduate university students at a European level. We try to recognize the first works performed by those people in different scientific fields every year.

We have also the European Science and Technology Week. It is constituted by a short series of events – about ten events a year. These take place simultaneously in the second week of November in 20-30 European cities. So there are more cities than events because some of the events have preparatory phases in different places. The European Science and Technology Week is specially aimed to attract the attention of young people to science and technology. But the European S&T Week would only add some more drops of water to the ocean of these activities in Europe, if the Commission would have not undertook the open coordination of similar activities in member states and in the associated states. This coordination may allow the exchange of successful events and also to bring force in the international dimension of national science and technology weeks or festivals. You know very well that if there is something really-really international, that is science. There is no German science, French science an American science, there is only science at which every country contributed through their different national cultures. So we expect a lot from this coordination of national science and technology activities in Europe. In addition to that, raising public awareness may also economically support the organization of thematic networks to exchange good practice and experiences in the field of science communication.

We have written in the EU Directorate "Science and Society", which is ultimately responsible for the set of activities I mentioned, an Action Plan which describes a set of 38 actions. About half of them are dealing with science communication and probably more than third of them are directly connected with the interest of young people for science and technology and the development of the possibilities for young people to work in this field.

I will be here until the end of the workshop so I will participate formally in the discussions and I can provide you more detailed information that I wasn't able to convey you during this short introduction in the opening ceremony. Thanks a lot!

Ragnhild SOHLBERG
NATO representative

Dear Mr. Under Secretary of State, Ladies and Gentlemen!

I am participating in this Advanced Research Workshop (ARW) because recently I became a member of the Advisory Panel of NATO Science Program's, "Science Technology Policy and Organization (STP)", which is the major sponsor of this meeting. The NATO Science Program attempts to have Panel members represented at all major events and due to my great professional and personal interest in the subject matter, I became the lucky one to participate here.

I am also very much involved with the EU Commission DG for Research. The Commission recently launched its Science and Society Action Plan. In connection with this involvement I participated last year in the EU Contest Award Ceremony for "Young Scientists", which was held in Bergen. Here I applauded for Balint Pato twice, and since he is one of the student participants in this meeting, I am glad I now finally have the opportunity to meet him.

First a few words about the NATO Science Program. It was founded in 1958 after the Sputnik experience with the establishment of the NATO Science Committee following the recommendations of a special committee on "Non-Military Cooperation in NATO". The report of that special committee of three wise men: the Foreign Ministers from Canada, Italy and Norway, asserted that progress in the field of science and technology can be decisive in determining the security of nations and their position in world affairs. The Science Committee immediately recognized that the training of young scientists and engineers is of paramount importance, and introduced a group of support mechanisms which in essence remain the same today.

Since the early 1990's and due to the political changes, the NATO Science Program has served a wider scientific community, as also scientists from 27 Partner-countries of the Euro-Atlantic Partnership Council have become eligible for support. 1999 was a landmark year, in that, with the exception of a small number of fellowships, the Science Program was transformed so that support is now devoted to collaboration between Partner-country and NATO-country scientists or contributing towards research support in the Partner-countries. About ten thousand scientists are currently involved in the Science Program each year, as grantees and meeting participants or as referees or panel members.

The importance of training young scientists and engineers has been understood for several decades. However, due to demographics and – as Gregorio Medrano-Asensio also mentioned – due to the development in science and technology as well as the associated knowledge-based economy, and due to the fact that technology permeates our everyday life, most nations worry about the growing gap between the demand for and the supply of experts and trained individuals in the fields of mathematics, science and technology. In addition, the relationship between science and society has undergone a change, leading to a great need for public understanding of science and technology. Neither science nor scientists – nor industry (where I come from) – exist in a vacuum. Also democracy requires that the public and the policy makers are able to make choices from the options made available to them by responsible scientific and technological progress.

On the other side of the Atlantic, in the USA the National Science Foundation has recently launched the new "Mathematics and Science Partnership Program". This program is part of president Bush's initiative "No child left behind!", which states that the US has "fallen short in meeting [its] goals for educational excellence".

The objectives of new initiatives and investments in Europe and in the USA are to improve the citizen's scientific and technological proficiency as well as general literacy, and to enable all citizens to understand and take advantage of basic concepts of science and math.

In the program of this Advanced Research Workshop it is said: "Science education is an important element of recruitment of future generations for scientific research." This is clearly correct. And the aim of this workshop is to bring existing practices of highly successful education and research training in NATO countries to countries which until recently have had different social and educational structures, that is the nations of Central and Eastern Europe. But as I am sure you are already aware of, three things should be kept in mind: (1) In spite of the many good examples, the major new national and international initiatives described above, indicate that the Western European nations and the USA have not been all that successful. (2) What may be successful at one time or in one place may be a failure or inappropriate at another time or another place. So the degrees to which policies and practices are successful or not, depend on the local, national or regional culture and framework conditions at a given time and place. While good practices should and can be learned, these practices of others cannot be directly adopted, they must be *adapted* to the local circumstances. (3) The greatest challenge facing many countries today may be to recruit a qualified, motivated and educated science and math teachers, a concern that I would have liked to have more time to elaborate on.

So thank you very much, Peter, and to your excellent staff!

I wish all of us a successful, and long remembered, rewarding workshop!

Diana MALPEDE
UNESCO representative

Peter a few minutes ago referred to my presence here and said: Diana will tell you, why UNESCO is here. I realize that it is very difficult to say why UNESCO is here, because there are a lot of reasons, and I don't know where to start. Because I am an Italian, which means that I decide to do one thing, and then do another thing: just to explain why UNESCO is here I will read now, what I had planned to read at the end of my intervention. I think it is a good synthesis, why UNESCO is here. I found these words of Mendelejev very suitable for this purpose: "Science and technology and various forms of arts all unite humanity in a single interconnected system. As science progresses, the worldwide cooperation of scientists and technologists becomes more and more a special and distinct intellectual community of friendship in which in place of antagonism there is a growing mutually advantageous sharing of work, a coordination of effort and solidarity, which are in many case independent from the social and political differences of the individual states." I think if we pick words of this sentences, they contain all the reasons, why UNESCO is here. First of all: friendship and partnership. UNESCO is the house of partnership and cooperation. Second: sharing the work. UNESCO is to organize the sharing of the work for mutual understanding. Third: solidarity, efforts and commitment. The commitment of UNESCO for science was expressed in the World Conference on Science in Budapest. So this is why UNESCO is here.

The Budapest World Conference on Science started a chain of events, which all strengthened the commitment for science and society. For UNESCO science is not only for scientists but for the whole society. As a part of this we had the fantastic adventure with Peter, and others from both Budapest and many many other parts of the world: the International Forum of Young Scientists. This is a Forum, which is growing and thanks to the Hungarian authorities it has now an established secretariat in Budapest. UNESCO is happy to greet this development. So it is a must for UNESCO to be present in Budapest, when something important happens concerning science and society as well as science and young people. And this meeting is really important.

Another reason why UNESCO supports this kind of initiative is education. In the family of the agencies of the United Nations UNESCO is the leader of the issues on education. The specificity of UNESCO on this issue is interdisciplinarity. We have the advantage to link the different fields of culture, communication and science in order to make real interdisciplinarity and transdisciplinarity, which are the fundamental elements to deal with global problems.

Still another reason from the many: public understanding. We hope that the new event, which will be organized by UNESCO for the first time on the 10th of November this year, the World Science Day for Peace and Development will bring together a lot of people to celebrate science and to demonstrate that it is a joint adventure. This World Science Day will be a huge set of local events in various nations. We see this celebration not only as a one-day celebration, but as an occasion to start a progress of a novel partnership linking different organizations.

The last, but not least reason is youth. Youth is a priority in the strategy of UNESCO. There are many specific programs concerning youth, and also the "youth aspect" of all general programs conceived as a more and more important requirement before adoption of these programs.

This list was not complete at all, but I think where people share friendship, cooperation, and a common vision of future: UNESCO must be there. Thank you very much!

Benito RIGHETTI
Scientific Attaché of the Embassy of the Italian Republic

Thank you Peter, for introducing me. Very distinguished Authorities! Ladies and Gentlemen! Young and talented people! I am very glad to be here, to attend this meeting and to feel the pleasure we have some role in supporting this very important initiative favoring young generation committed in science.

First of all, let me convey you the best wishes and greetings on behalf the Italian Ambassador, who could not attend this meeting. Prof. Gabor Szabo said at the beginning that we are often committed in representing our authorities, which is a pleasure and honor; in the other side it sounds a hard job to speak on their behalf.

I am the Science and Technology attaché of the Italian Embassy so I feel home here and very much involved: I am in charge of promoting science and technology cooperation between Italy and Hungary but also with a special task of extending this cooperation within all Central and Eastern European countries. This is the important topic, which has been stressed when the Italian Ministry of Foreign Affairs agreed to sponsor this symposium. We are all aware that in modern times the cooperation is a key tool for Science development.

Let me mention that scientific cooperation between Hungary and Italy is having a long history. Italy was the first western country, which signed an agreement for science and technology cooperation with Hungary already in 1965, which finds its roots in an extraordinary cultural cooperation between the two countries dating back to the Middle Age. Of course in the last 35 years much has been changed in the protocol for the implementation of the Science and Technology Agreement. This event is a clear demonstration of how new policies, strategies and tools affected science development during these years. The agreement for science and technology emphasizes the aspect of innovation and technology transfer, economic development in terms of joint venture establishment, of quality of life improvement (environment, medicine, energy, sustainable agriculture, etc.). However, another aspect of great and growing significance, is the training of young people, according to the main topic of this meeting

We are already much involved in mutual cooperation in training young talented people of Central-East European Countries how to start new enterprises and new innovative business in Europe mainly in the areas of environment preservation and recovery, medicine and new biotechnology. In such a context I find very appropriate what is mentioned in the provided summary of the event and very focusing the aim of this workshop: "disseminate the experience of highly successful scientific research training projects to Central and Eastern Europe. The project will establish a network of scientific research training programs worldwide helping the organization of new programs and promote the regular contacts of students and teachers". This is an excellent program, and we are happy and honored to give our contribution and support to this as well as to the next events. This has a special meaning now, since most of the people in Central Eastern European countries are applying to join the European Union. This program will help young people to find a good way to increase cooperation in our Europe. Thank you very much for your attention!

Leon LEDERMAN
Nobel-laureate
Illinois Mathematics and Science Academy, USA

In the aftermath of 9/11, so many things changed and one major recipient of new attention is the subject of science and of education. We have, in our histories, so often looked to rationality, logic and the transcendental beauty of nature revealed as a solution to human problems. But 9/11 has begun to teach us just how crucial these aspects of culture are to our survival. As the Workshop proceeds, it would be fascinating to weigh the presentations as constructs in the hope for someday achieving a more just, equitable and therefore peaceful world. But above all I hope you learn and enjoy!

Session II

Gifted Children: Recognition, Problems, Coping

This page intentionally left blank

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Scientific Thinking in Gifted Children

Joan FREEMAN
Middlesex University, 21 Montagu Square, London W1H 1RE, UK

Abstract. The intellectually gifted are different in their learning. They not only have exceptional thinking and learning abilities but also use them more effectively, and can more readily adopt scientific thinking. In a Follow-up study Freeman found that youngsters of high intellectual ability reported exceptionally effective intellectual strategies. They also knew both how to motivate themselves to study as well as their personal learning style, though these could be inhibited by emotional disturbance. Evidence from international studies, along with the lessons from these highly-able learners, provides insights into scientific learning strategies for all children.

1. Introduction

If, as the evidence indicates, the intellectually gifted think and learn differently from others, then it is important to teach them appropriately. Scientific thinking is not confined to scientists. Even for small children, scientific thinking means using a critical analysis of ideas and trying out hypotheses against data to see how they fit into the known world. But at school, and particularly in higher education, most of us are taught to think in such a hyper-critical way that it tends to reduce the richness of ideas to just the skeleton of their construction both in creative production and in receiving ideas from other sources.

The problem is how to reach the right balance in scientific thinking, using not only critical faculties but also creative ones which connect with other forms of knowledge and creative ideas. Without creativity in scientific thought there is no revolutionary scientific advance, which according to Thomas Kuhn, the philosopher and the inventor of the paradigm shift, occurs when a new paradigm emerges and becomes accepted by the scientific community, which must, of course, be open to it.

Internationally, giftedness is most frequently determined by a score on an IQ test which is above a chosen cut-off point, usually at around the top 2- 5%. Children's educational environment contributes to the IQ score and the way intelligence is used. For example, a very close positive relationship was found when children's IQ scores were compared with their home educational provision (1). The higher the children's (Stamford-Binet) IQ scores, especially over IQ 130, the better the quality of their educational support, measured in terms of reported verbal interactions and activities with parents, number of books and musical instruments in the home etc. Because IQ tests are decidedly influenced by what the child has learned, they are to some extent measures of current achievement based on age-norms; that is, how well the children have learned to manipulate their knowledge and know-how within the terms of the test. The vocabulary aspect, for example, is dependent on having heard those words. But IQ tests can neither identify the processes of learning and thinking nor predict creativity.

Gifted children are defined here in two ways (2). Firstly those who either demonstrate exceptionally high-level performance whether across a range of endeavors or in a limited field. Secondly, as those whose potential for excellence has not yet been recognised by either tests or experts. Yet excellence does not emerge without appropriate help. To reach an exceptionally high standard in any area very able children need the means to learn, which includes material to work with and focused challenging tuition – and the encouragement to follow their stars.

2. Barriers to scientific thinking

2.1. Barrier one – uncontrolled emotion:

Scientific thinking depends on strong cognitive processes, so that relatively more imaginative and constructive options are used in decision-making than emotional reactions, though those are also part of the decision-making. For example, in a dispute one would not just think 'I'm for it' or 'I'm against it', but come up with options like these which employ both sympathy and reason.

- I understand, but stop arguing until people cool down
- Compromise: start with a clean slate and a new policy
- Ask a trusted friend or colleague to referee
- Insist on the point at hand, but make a concession on something else

2.2. Barrier two - common sense

Not only can emotion get in the way of scientific enquiry, but so does 'common sense' But what one person sees as 'common sense' another can see as biased and stupid. For example, whereas in one family success is seen as due to hard work, in another it may be seen as all down to luck. In an English experiment to test the understanding of flotation, pressure, motion and shadows, 24 children aged between 9-14 were interviewed then asked to experiment to see whether their original beliefs were correct (3). Very few understood that to find out which of the variables were influencing the results it was necessary to manipulate that variable, and that variable only. So many ideas in the form of extraneous variables were introduced that the children had great difficulty with the experimental processes of predicting, observing and drawing conclusions.

3. The promotion of scientific thinking

3.1. Self-regulation

The equation appears to be relatively straightforward: the more able an individual the more self-regulation in learning will be needed for high achievement; the less able an individual, the more teacher regulation is needed (4). There appears to be a qualitative difference in the way the intellectually highly able think, compared with more average-ability or older pupils, for whom external regulation by the teacher often compensates for lack of internal regulation. To be at their most effective in their self-regulation, all children can be helped to identify their own ways of learning – metacognition - which will include strategies of planning, monitoring, evaluation, and choice of what to learn. Emotional awareness is also part of metacognition, so children should be helped to be aware of their feelings around the area to be learned, such as curiosity, persistence, and confidence.

High achievers have been found to use self-regulatory learning strategies more often and more effectively than lower achievers, and are better able to transfer them to novel tasks, to such an extent that measures of autonomous learning could even indicate talent. Overviewing research on the thinking processes of highly able children (5) put the teacher's problem succinctly: 'If they [the gifted] merely think more quickly, then we need only teach more quickly. If they merely make fewer errors, then we can shorten the practice'. But of course, this is not entirely the case; adjustments have to be made in methods of learning and teaching, to take account of individual thinking differences.

Yet in order to learn by themselves, the gifted do need some guidance from their teachers. Conversely, teachers who offer too much direction can diminish their gifted pupils' learning autonomy. Although 'spoon-feeding' can produce extremely high examination results, these are not always followed by equally impressive life successes. Too much dependence on the teacher risks loss of autonomy and motivation to discover.

When teachers help pupils to reflect on their own learning and thinking activities, they increase their pupils' self-regulation. For a young child, it may be just the simple question 'what have you learned today?' which helps them to recognise what they are doing. Given that a fundamental goal of education is to transfer the control of learning from teachers to pupils, improving pupils' learning to learn techniques should be a major outcome of the school experience, especially for the highly competent. There are quite a number of new methods which can help, such as child-initiated learning, ability-peer tutoring, guided dialogue, etc. Such practices have been found to be particularly useful for bright children from deprived areas.

Methods to promote self-regulation in learning (6)

- *Talking aloud.* The teacher talks aloud while working through a problem so that the pupil can see the working.
- *Cognitive apprenticeship.* In this the teacher demonstrates the processes that experts use to handle complex tasks, guiding the pupil via experiences.
- *Discussion.* This must involve analysis of the processes of argument.
- *Cooperative learning.* The pupils explain their reasoning to each other. Cooperative teaching-learning interactions in the classroom are ideal for helping pupils take the leap to higher levels of understanding.

- *Socratic questioning*. In this, the teacher uses careful questioning to force pupils to explain their thought processes and explain their arguments. The questioning is not used to teach new knowledge, but to help pupils to know and use what they already have.

3.2. Meta activities

The degree to which high-level scientific thinking can be strengthened and mobilised depends on developing the meta-activities needed for autonomy in learning. This not only involves the metacognitive overview and direction of one's own thought processes, but also a mixture of attitudes, such as curiosity, persistence, and confidence, as well as the use of strategies, such as planning, monitoring, and evaluation.

Applied research into how children learn science brought Adey (7) to the conclusion that "the children's ability to think about the nature of their own thinking was a critical contributor to their success" (7, p.28). In CASE (Cognitive Acceleration through Science Education) work, "students are encouraged to take time to reflect on how they solved a problem, what they found difficult about it, what sort of reasoning they used, how they sought help and what sort of help they needed" (7, p. 6).

But scientific progress is not all theoretical, knowledge is vital to outstanding performance: individuals who know a great deal about a specific domain will achieve at a higher level than those who do not (8). Research with creative scientists by Simonton (9) brought him to the conclusion that above a certain high level, personal characteristics such as independence seemed to contribute *more* to reaching the highest levels of expertise than intellectual skills, due to the great demands of effort and time needed for learning and practice. Creativity in all forms can be seen as expertise combined with a high level of motivation (Weisberg, 10).

So, learning is not just a matter of cognitive processing; it is affected by emotions of both the individual and significant others. Positive emotions facilitate the creative aspects of learning and negative emotions inhibit it. Fear, for example, can limit the development of curiosity, which is a strong force in scientific advance, because it motivates problem-solving behaviour. In Boekaerts' (11) review of emotion in the learning of very high IQ and highly achieving children, she found emotional forces in harness. The children were not only curious, but often had a strong desire to control their environment, improve their learning efficiency, and increase their own learning resources.

3.3. Novices and experts

The difference between a novice and an expert is that the expert has a much broader knowledge base on which to use the same level of intelligence and creativity. For scientific thinking, the novice has to accumulate not only more information, but also the increasingly complex procedures to apply it to a greater variety of problems. Any expert action, such as high-level examination achievement, requires both knowledge and the skills to use it. In well-practised everyday activities like making a phone call or driving a car, everyone makes use of such expert actions. It is even possible to develop general adaptable expert strategies for problem-solving. Professional administrators have a selection ready to apply in very different fields of activity and situations. This is why a competent manager can move with good effect from, say, a factory producing glassware to a business buying and selling cloth.

One can think of children as novices and adults as experts, and gifted children may become experts well ahead of their years. This may mean an advanced ability to see relationships between objects and to apply them in new situations. A gifted child may even jump whole stages in an argument or logical progression, though may be unable to describe how he or she reached those conclusions. This can be disconcerting to adults. A child may also see ambiguities in questions which others do not see, needing time to pause and consider before answering and maybe appearing to be slow in responses.

However, it is usually agreed that even though a child may give adult-expert type performances, such as Mozart and Mendelssohn did in their early musical compositions, those works were in fact the products of infant prodigies and do not compare in depth either to their own adult works, or the work of other composers in their adult years (12).

Advanced thinking in children can be seen in terms of problem-solving skills (13). The level that can be reached depends both on knowledge and the quality and efficiency of its mental organisation - vital in high-level scientific thinking. Even young gifted children show a distinctly more mature, expert-type competence in information-processing than their non-gifted age peers. Thinking techniques used by the gifted have been found to have a degree of sophistication normally used by older children of average IQ. Ferranti and Butterfield (14) found a clear IQ correlation with the levels of sophistication of the children's thinking approaches.

Differences in problem-solving strategies between high and average school performers were investigated by Shore, *et al,* (15), who audio-taped and analysed the young pupils' thinking-aloud comments. The researchers found that the performance of the more successful learners was closer to that of experts, in that they made more reference to prior knowledge, rather then only to information presented in the problems (16). However, others have concluded that the learning procedures of the highly able are distinct in style, rather than simply being more mature (17).

There is a growing body of evidence that both metacognition and motivation are shaped by culture (18). For example, Schneider (19) found that German children were more likely to use memory strategies and recall significantly more material than Americans. These characteristics were traced to differences in home and classroom. German parents reported more direct instruction of strategies were more likely to check their children's homework, and possessed more games in which strategic thinking was required. The trend for teachers was the same; they were more likely to direct memory strategies.

4. Freeman's follow-up of gifted and non-gifted youth

The uniqueness of this 27-year follow-up study has been in the in-depth, counselling-style interviews, with gifted and average ability young people, their teachers and parents, about the fabric of their lives, each one in their own home across Britain (1). 210 children entered the study in 1974 aged 5-14 years-old. Hundreds of hours of follow-up interviews were audio-recorded and keyed in to a computer to be analysed. Part of the research was concerned with their thinking and study habits, illustrated briefly here.

It was clear that when a child's educational environment was inadequate for learning and mental exercise, the development of metacognition was impeded. So, children of high potential living in culturally poor circumstances which detracted from their energy and positive attitudes to learning needed much more teacher assistance. Those who were intellectually gifted and achieving at a high level often had an advanced degree of awareness of their mental processes, so they could function nearer to their best for longer than the others in the sample. They told it in their own words, as one gifted mathematics student at university said:

> "The secret of my learning is that I've got to understand what I'm doing. For me, there are two approaches to work. If it's a subject that bores me, or a problem I find difficult to understand, I know I have to plough through it, referring to notes and back, just learning by heart. But if it's something I enjoy, like maths, I just sit back, look for the important points, and I can do it."

4.1. How the gifted learn

To different degrees, about a dozen gifted youngsters in the sample had allowed their study habits to become really rigid, and relied heavily on their exceptional memories in a relatively superficial and unthinking way though rote-learning, memorising pages of information. Such habits are not only inefficient in the long term but very boring, and so detract from the pleasure of learning. Their attraction is that it appears to require less effort from both learner and teacher. It also offers the learner an immature, spurious emotional security, in that he or she does not have to make their own learning decisions, but only reproduces what an authority such as a teacher or text-book writer has said. In the panic before big exams, even the most sophisticated thinkers in this study sometimes abandoned their valuable, higher-level strategies for a frenzied, indiscriminate search though their notes.

Even when he was 10, I had observed that Neville, who had a top-of-the-scale IQ, also had an anxious personality and natural reserve, which seemed to have been reinforced by unrelieved school pressure to absorb information. He was aware that he used the false security of rigid, learning strategies as a shield to hide from his emotional self. No-one had ever helped him develop a feeling of competence in his own thinking so that he could use his extremely high potential in a flexible and productive way. As a science specialist, his school had obliged him to drop all the arts subjects, and he had developed little insight into or love of the more creative aspects of life. At university, Neville was becoming desperate about what he felt was missing from his life, so much so that he was considering dropping-out before his finals (he didn't). Nor had his study methods improved, his poor (but examination effective) learning habits had become ingrained. He looked at the ground when told me despondently:

> "I don't read textbooks: I'm not very good with them. My notes are so vast, 50 pages of dense writing. I go through them again and again, just writing down occasional sentences. I learn all those, and then go through problem sheets and exam papers."

4.2. Lack of discipline

Although Samantha had achieved superb school-leaving grades, her poor metacognition, her lack of awareness of how best to use her powerful mind, showed up when she had to survive on her own at university.

> "People say I'm weird because I will think of something which will remind me of something else, then my mind will go racing along the new train of thought. I'll arrive at an observation which has got no relevance to anything that anyone else can see. It's a handicap when I'm trying to learn, because, say I'm looking something up in an index, I'll be triggered into finding something else to look up, but then I won't get back to the original thing for hours. I still have to rely on my memory.
>
> Until I got to university I'd never actually had to work - I did my homework on the bus or while eating my tea. It was never difficult. When I started my degree course, I tried to do the same with the first maths problem sheet we were given. I soon realised that this was 'hard'! And most of the others on the course had been used to finding this stuff hard, and settled down to work at it. I'd never had to learn how to work - and being away from home at the first time, at the age of 17, is not the best time to have to do that! So I never really put in the necessary effort, right from the start. And that's why I failed."

4.3. Overdoing it

Alternatively, the intellectually gifted are sometimes faced with the temptation of frenetic mental activity, which may not appear to be to any productive purpose. It seems to happen when the emotional part of a person either becomes disregarded or actually crippled, as though it were irrelevant to the individual's thinking and creativity, almost as though someone has become just a brain physically supported by the rest of the body. Such a person can enter a maze of ideas, developing theories and sub-theories which have no useful function other than intellectual exercise. William Sidis, the American genius who supposedly had one of the highest IQs ever measured, found himself trapped by such mental convolutions. His upbringing had led him to believe that he was only valued for his intellect, compounded by the devastation of his peace of mind though his media fame for being brilliant. His relatively little productive work has not withstood the test of time (20).

Stephen Harris, a supremely gifted 14 year-old, showed evidence of too much dependence on his cognitive skills. He was the child of warring divorced parents, somewhat emotionally neglected and lonely. He told me:

> "I learned to programme when I was eight. Now, I'm working out a formula to translate into computer language. It's quite a simple programme, finding elements in Pascal's triangle. But the thing that made it a lot more complicated was that I wanted to do it for very large numbers, so it required a different method of storage from the ones the computer actually provides for you. At the moment, I'm working on a version of Manic Minor, a computer game on a large scale with 50 different screens. I invented a card game once called Seven Card Wiggle and typed the rules for that, which I don't think I'll ever finish because there are about seven thousand."

By his thirties, Stephen had taken a job much below his abilities, and though it was somewhat boring, it brought him a steady salary so that he could return home at the end of the day in a peaceful state. He knew quite well that he had no wish to return to the emotional turmoil of his childhood, and if the price to be paid was a dull life, then that was what he had chosen.

Similar evidence of emotional insecurity and dependence on purely cognitive skills can be seen in many high-level school-achievers as they go through life. Rather than daring to create ideas, they seem almost desperate to show how much they know by answering other people's questions correctly and being informative, as though life was one long educational grilling on which they were to be judged. This situation was described in a follow-up of 1964-1968 Presidential Scholars in America (21). Kaufman found that although the ex-scholars continued to do well, they knew they often relied on school-type learning, not only to provide themselves with an identity but also a feeling of worth. But then, at any age, being a 'know-all' is not perhaps the best way of attracting friends.

4.4. Good strategies

The most frequent strategy used by the successful young people in Freeman's study was to look for the principles in their work first, and then fill in the details appropriately. To do that calls for the confidence to take an authoritative overview of both the subject under consideration and of one's own mental approach. Jacob, a gifted flexible learner and a confident scientific thinker, studying medicine, said:

> "I'm a great believer in trying to find a rule that makes things work. I can very often remember the principles first time through. I certainly avoid learning things by rote."

4.5. Multi-attention

The ability to be focussed has its advantages, in that greater progress can often be made in the desired direction. But working in several areas at once is also useful in both intellectual and practical ways. Mary, with her top-of the scale IQ, was at university studying Computer Systems Engineering. She explained:

> "I often do two things at once. Right now I'm building a synthesiser, so I've got piles of components and bits of things to stick to this piece of board. Unfortunately, as I haven't got all them all it's a bit difficult trying to imagine where they're going. I've brought it home to do, so I do it while I watch television. I like to have something on in the background, because it's a boring job; the first component in is much like the eightieth component in."

4.6. Speed of thinking

A high proportion of these gifted young people could think very rapidly. Mary continued:

> "At school I was in a small class so I went at my own speed. I would say to my teacher, 'I think I know this well enough now', and we would move on. But at university it's mixed ability, everybody in one class. There are 25 of us on our course, and we're spread out across the whole ability range. Those who want to

work quickly can get on and then take more free time than others. But I'd really prefer to be in a group where everybody wants to work quickly.

> I like working quickly. You don't sit next to Mary unless you want the answer before you've started the problem! I sit there, and the question will be written on the board, and before the lecturer's finished the question, I've started writing. And while everybody else is writing down the first formula, still wondering what to do, I'll say, 'Finished!' But that speed only works for logic and maths because it's numbers and figures and symbols. Something I could do symbolically in a couple of minutes might take me upwards of half an hour to explain to somebody else. Anything where I've got to express my own ideas and explain why something happens, or write an essay, takes a lot longer, because you've really got to stop and think.
>
> I find it very hard to stop to think in the middle of a flow. I'd much rather get it down, then go back and check through every step. In an exam, I'll whiz through the paper, spending about two-thirds of the time writing, and the other third going through, checking my answers and often changing things. It's a case of, does it feel right and does it make sense?"

The high-achievers in this sample often had a good grasp of their own metacognition - knowing how they learned and thought, and with the ability to work in ways which suited them. They were often able to describe their systems explicitly, and say how it could affect their results. In that way they could harness the mental power they were born with in hard work that was well aimed and coordinated, although very few had been taught how to do it. They were also much more keenly aware of different possible approaches to the work than the relatively less successful students, who had to use more energy to cope in a more rigid way with less success in their learning.

Mary the computer student explained:

> "Everyone knows which is the best way for themselves to work. Children have got to choose their own way, otherwise they're not going to do their best, and it may be difficult for them to express themselves in a way which doesn't fit their style. I would have liked the teachers to know what we thought. It would have been nice for us to have been able to say, 'Look, I don't like the way it's done. Is there nothing we can do to change it?'"

4.7. Concentration

While some of the most gifted said their normal attention span was only a few minutes at a time with constant breaks, others claimed many hours of unbroken concentration. Others described how they could adapt to whatever the circumstances called for, altering the length and depth of concentration appropriately.

It can vary, as a gifted boy said:

> "I usually take breaks about every ten minutes. Once though, I worked from four o'clock when I got home, till half-past one in the morning, and then had my break for tea. I concentrated totally. It was just something that had to be done."

Some took this to extremes, such Jacob, the top-of-the IQ scale medical student:

> "I've got exams in three or four weeks, and I'm being quite honest when I say that I haven't opened a book all year. I like to feel the pressure, to build up some anxiety, so I know that if I don't start now, I'm definitely going to fail. It's the challenge of doing that. I'm fully dedicated to working at this point, and only at this point. For my first year exams, I only started revising two days before. My method is to cram for couple of weeks, doing 24 hours a day, and not sleep for a few nights. I'm a totally different person when it gets to that stage. Everything seems to go in at that point, so I must be able to absorb the stuff."

5. Examples of educational schemes for encouraging high-level scientific thinking

It is clear from the evidence that excellence in any sphere does not emerge without appropriate help. If the recognition of high-level potential is restricted to school and test achievements, much will be missed. To reach an exceptionally high standard in any area, potentially gifted children need the means to learn; this includes the material to work with and focused, challenging tuition, sometimes including tutoring or mentoring that is not provided in normal schools. It is suggested that given the opportunity and with some adult guidance, children of high potential and motivation should be able to choose to work in any area at a more advanced or deeper level.

Every school should have a clear policy for the encouragement of high-level performance in both pupils and teachers. Such a statement would also provide an indication of how the school deals with the different educational requirements of all its children. Any policy must also involve the commitment of the head-teacher and a whole-school approach.

Rather than continuing the search for elusive definitions, it would be more productive to look at the dynamic interaction between individuals, and their opportunities for learning throughout life. Without that dynamic element, we return to the old ideas of fixed abilities, most notably of intelligence. What is needed to enhance every child's potential is often already available, at least in the developed world.

5.1. Cognitive Acceleration through Science Education (CASE)

Cognitive Acceleration through Science Education is a British system used in several countries, which has sound experimental evidence to back its aim of improving scientific thinking (22). Part of its design for increasing scientific thinking in school-children, is to speed up their "'natural' development process through different stages of thinking ability, towards the type of abstract, logical and multivariate thinking which Piaget describes as formal operations. Formal operational thinking is characterised by the ability to hold a number of variables in mind at once – for example, to be able to weigh up two sides of an argument, to consider even-handedly the advantages and disadvantages of a particular course of action, or to be able to see both the separate and combined effects of a number of input variables (for example – sunlight - carbon dioxide - water) on an outcome (the production of glucose)." (22, p.5)

In spite of being based on Piaget's theory of stages, the CASE intervention procedure rejects the simple idea of matching learning material to the stages because that keeps cognitive demands at the same level as the current level of the learner's thinking. Instead, it uses Vygotsky's concept of Zone of Proximal Develoment - the difference between what a child can do unaided and what a child can do with the help of an adult, (as does Feuerstein's programme of Instrumental Enrichment). The teacher structures the lessons for higher-level thinking, but cannot independently put capability into a child's head. The child must do this alone, which can take time and patience.

CASE distinguishes between staightforward instruction - aimed at content objective - and intervention in the cognitive development process - aimed at raising levels of scientific thinking within the curriculum. It challenges learners to transcend their present level of thinking and speed up their rate of intellectual development.

Selection procedures which choose children by their current achievements, rather than what they might be capable of doing, such as in the vast majority of standardised tests, will inevitably miss children who are not functioning at their best.

5.2. A self-selection scheme for learning science - Migal

Opportunities for potential ecologists are provided by Migal at The Technological Centre for the Galilee, Israel. For about 20 years, the Centre has invited teenage boys and girls from local comprehensive schools to work on their own projects under supervision. They are not pre-selected in any way. The Centre has the specific aim of developing scientific thinking, using projects such as the effects of magnesium on plants, or cultivating wild mushrooms, or the effects of hormones on fish reproduction. In the laboratory, youngsters design and conduct work on original problems for which there are no existing answers, nor (often) methods, then continue to work with the data back at school. The teenager has to prepare and write a research proposal, which is discussed with the laboratory supervisor, and submitted to the Ministry of Education for approval; then, he or she can begin, either alone or in a group. Each participant has to be able to work on a computer, and eventually will provide a bound dissertation. The Centre displays the youngsters' work, which is sometimes of Master's degree standard. This shows what can happen when motivation is allied with opportunity, and the potential to take advantage of it. The cost is low and largely supported by the state, and the results are extraordinarily high.

5.3. The Sports Approach to promoting gifted learning and thinking

Excellence in some abilities is more acceptable than others in all cultures. In almost all parts of the world, local education authorities encourage enthusiastic, talented footballers to benefit from extra tuition outside school hours. They are provided with equipment (possibly including clothing), transport is arranged for them to meet and play with others at the same level as themselves, and it is all paid for by the local authorities.

There is some provision around for other subjects, notably music, and there are mathematics contests and extra-curricular activities, such as art classes in museums. Too often, school laboratories remain closed out of school hours. It is neither difficult nor expensive to find out what interests and motivates pupils via questionnaires, interest tests, or simply by asking them. The facilities are already largely in place to provide excellent support for gifts other than football.

Freeman (2) has proposed that, given the opportunity, and with some guidance, the gifted (and motivated) should be able to select for themselves work at any subject at a more advanced and broader level. She terms this the 'Sports Approach'. The model works in the same way as school attitudes to sport. Just as youngsters who are talented and motivated can select themselves for extra tuition and practice in a particular sport, they could opt also for biology. This would mean that facilities must be available to all, as sport is, rather than only to those pre-selected by tests, experts, or money

This is neither an expensive route, nor does it risk emotional distress to the children by removing them from the company of their friends. It makes use of research-based understanding of the very able, notably the benefit of focusing on a defined area of the pupil's interest, as well as providing each individual with what they need to learn and make progress.

However, to practice the Sports Approach, most teachers would need more training in differentiated teaching methods and techniques for bringing out high-level potential. But most importantly there would have to be some unification of policy within a school or authority. The recognition of talent in this way would also include recognition of the learning plan to which the pupils had access. This could be done by a simple rating-scale; children who were excelling within their context would be seen to be doing so, and not penalised because they had poorer provision than others. By such means, the proportion of those we now consider to be gifted could be considerably increased, to the greater benefit of all concerned. There are, however, certain guidelines to be aware of in this approach.

6. Identification and development of gifts through provision:

- Development should be process-based and continuous.
- Identification should be by multiple criteria, including targets for learning and outcome.
- Indicators should be validated for each course of action and provision.
- The pupil's abilities should be presented as a profile, rather than a single figure.
- Increasingly sharper criteria should be employed at subsequent higher-level learning stages.
- Recognition should be given to attitudes possibly affected by outside influences, such as culture and gender.
- The pupils must be involved in educational decision-making, especially in areas of their own interest.

7. Internet help for scientific thinking

There are many sources of rich encouragement and provision for inspiring potential scientists to be found on the world wide web. For example -

An initiative based at Sheffield Hallam University, the *Pupil Researcher Initiative* or *PRI* (http://www.shu.ac.uk/schools/sci/pri/welcome.htm/) sponsors science fairs, and presents pupils with challenging, relevant investigative tasks. The activities presented in the *PRI* units of work should help teachers to prevent boredom amongst their more gifted pupil scientists.

The Eco-Schools project (http://www.abdn.setpoint.org.uk/setpoint/aberdeen/section/eco-schools/), the *Crest Awards* (http://www.nybep.demon.co.uk/STEM/CREST/CREST.HTM), and school industry links encouraged by local SATROs (Science and Technology Regional Organisation) encourage pupils to undertake extended, appropriate interesting projects of their own choosing. The *Crest Awards* also include an element of competition.

The British Association for the Advancement of Science (http://www.nybep.demon.co.uk/STEM/BAYS/BAYS.HTM) supports teachers wishing to run science clubs through the provision of special experiment packs. They also sponsor special events during science weeks, and their popular BAYSDAYS in national museums. Within these schemes, pupils can choose to pursue activities with a distinctive biological flavour.

The Internet gives pupils and their teachers access to working scientists through web sites (e.g. The Woods Hole Oceanographic Institute, on http://www.whoi.edu/science/B/dept/Biology_Staff.html).

Organisations such as the Association for Science Education also provide more direct access to scientists via the Internet during SET science weeks.

The Science museum inspired STEM project (http://www.nmsi.ac.uk/stem2/oyster.pl?stem/stemintro), is another useful source of challenging materials.

Science across the World project (http://www.ase.org.uk/sworld.html) presents pupils with the chance to participate in international data collection as individuals or as groups. The open-ended nature of the units of work facilitates data analysis at the highest level, and the project encourages links between like-minded pupils across the World. It thus encourages both child-initiated learning, and ability-peer tutoring.

References

[1] Freeman, J. (2001) *Gifted Children Grown Up.* London: David Fulton Publishers.

[2] Freeman, J. (1998). *The Education of the Very Able: Current International Research.* London: The Stationery Office.

[3] Howe, C. and Tolmie, A. (1999), 'Experimental appraisal of experimental beliefs in science: Constraints on performance in the 9-14 age group', *British Journal of Educational Psychology, 69,* 243-274.

[4] Span, P. (1995). Self-regulated learning by talented children, in J. Freeman, P. Span, and H. Wagner (Eds.) *Actualizing Talent: a Lifelong Challenge* (72-86) London: Cassell.

[5] Shore, B.M. and Kanevsky, L.S. (1993), 'Thinking processes: being and becoming gifted', in Heller, K.A., Monks, F.J. and. Passow, H.A. (Eds.) (1993) *International Handbook of Research and Development of Giftedness and Talent.* Oxford: Pergamon Press.

[6] Nisbet, J. (1990). 'Teaching thinking: an introduction to the research literature'. SCER *Spotlights*, 26.

[7] Adey, P. (1991), 'Pulling yourself up by your own thinking', *European Journal for High Ability*, *2*, 28-34.

[8] Elshout, J. (1995) Talent: the ability to become an expert, in J. Freeman, P. Span, and H. Wagner (Eds.) *Actualizing Talent: a Lifelong Challenge* (pp. 87-96) London: Cassell.

[9] Simonton, D.K. (1988). *Scientific Genius. A Psychology of Science*. Cambridge: Cambridge University Press.

[10] Weisberg, R. (1992). *Creativity, Genius and Other Myths*. New York: Freeman.

[11] Boekaerts, M. (1991). 'The affective learning process and giftedness', *European Journal for High Ability, 2*, 146-160.

[12] Radford, J. (1990). *Child Prodigies and Exceptional Early Achievers*. London: Harvester Wheatsheaf.

[13] Chi, M.T. H., Glaser, R. and Farr, M.J. (1988). *The Nature of Expertise*. Hillsdale, NJ: Lawrence Erlbaum.

[14] Ferrenti, R.P. and Butterfield, R.C. (1989). 'Intelligence as a correlate of children's problem solving', *American Journal of Mental Retardation, 93*, 424-433.

[15] Shore, B.M., Coleman, E.B. and Moss, E. (1992), 'Cognitive psychology and the use of protocols in the understanding of giftedness and high level thinking', in F. Mönks and W. Peters (Eds.) *Talent for the Future*. Assen: Van Gorcum.

[16] Luthar, S.S., Zigler, E. and Goldstein, D. (1992), 'Psychosocial adjustment among intellectually gifted adolescents: the role of cognitive-developmental and experiential factors', *J. Child Psychol Psychiat, 33*, 361-373.

[17] Kanevsky, L. (1992), 'Gifted children and the learning process: insights on both from the research', in F. Mönks and W. Peters (Eds.) *Talent for the Future*. Assen: Van Gorcum.

[18] Collier, G. (1994). *Social Origins Of Mental Ability* New York: John Wiley.

[19] Schneider, W. (2000), Giftedness, expertise, and (exceptional) performance: a developmental perspective, in K.A. Heller, F.J. Mönks, R. Sternberg and R. Subotnik (Eds.), *International Handbook of Research and Development of Giftedness and Talent* (pp. 165-177) Oxford, UK: Pergamon Press.

[20] Wallace, A. (1986). *The Prodigy. A Biography of William James Sidis, the World's Greatest Child Prodigy*, London: Macmillan.

[21] Kaufman, F.A. (1992), 'What educators can learn from gifted adults', in F.J. Mõnks and W. Peters (Eds.), *Talent for the Future*, Maastricht: Van Gorcum.

[22] Adey, P. (1999). *The Science of Thinking and Science for Thinking: a Description of Cognitive Acceleration through Science Education*. Geneva: International Bureau of Education. www.ibe.unesco.org

Talent, Science and Education: How Do We Cope with Uncertainty and Ambiguities?[1]

Katya STOYCHEVA
Institute of Psychology, Bulgarian Academy of Sciences,
Acad. G. Bonchev St., Blok 6, Floor 5, Sofia 1113, Bulgaria

Abstract. The paradigm of tolerance - intolerance of ambiguity is applied to the analysis of the relations between science education and talent development. First, I examine the role ambiguity tolerance plays in creativity and talent development. Second, I discuss research data and findings on the impact of education on tolerance of ambiguity. Finally, I propose a view on science education that links the promotion of scientific talent with public's understanding of scientific research.

1. Introduction

Uncertainty and ambiguities are implicit to human life. We have only limited control over the natural and social conditions of our life. Neither can we fully control our own behaviour and its effect upon environment, other people and ourselves. Our life is filled with ambiguous situations. These are situations where we have to act with lack of clarity or lack of information, and novel or uncommon situations where our true and tried, learned ways of thinking and acting do not solve the problem. Probabilistic natural events and human interactions with uncertain outcomes are also challenging us. Emotional ambivalence and cognitive incongruity are difficult to deal with. We often have to face fragmented or contradictory information that entails multiple meanings and which we cannot easily structure and understand (21).

Therefore we have to cope with uncertainty. We have to learn to live with ambiguities that are inherent to our life. Both individual and society have developed ways to deal with uncertainty and ambiguity, and both individuals and societies differ in the ways they do it.

---

[1] The preparation of this paper benefited largely from a NATO Scientific Research Fellowship the author carried out at the Laboratory of Cognition and Development (UMR 8605) at Université René Descartes in Paris, France, in 2001.

Individuals are more or less tolerant of ambiguity, and cultures are characterised by a different degree of uncertainty avoidance.

1.1. Individual's response

How people experience an ambiguous situation and what they do in such a situation is indicative of the degree of tolerance - intolerance of ambiguity they have. Individual differences in ambiguity tolerance manifest themselves in the content and the form of the representations that individuals create in ambiguous situations, in the direction of the actions they undertake, and in the accompanying affect (6,8).

People who are intolerant of ambiguity perceive and interpret ambiguous situations as a source of psychological discomfort or a threat, seem confused by ambiguity and tend to avoid it. When faced with ambiguity, they experience intense negative affects like anxiety and stress. Their reactions are defensive, disorganised and accommodation to the situation is blocked. Intolerant people are likely to arrive at "black-and-white" judgements, to reduce their view of the situation to certain, simple and familiar cues, and defend themselves through rigid, stereotyped behaviours which lead them to less than optimal solutions to the problem.

Conversely, tolerant people are better able to tolerate the feelings of anxiety and uncertainty induced by ambiguity. Their affective reactions are less intense and more varied. They will perceive and interpret an ambiguous situation more adequately, in a realistic way, without denying or distorting parts of its complexity. Tolerant people are likely to elaborate more adaptive and better co-ordinated behaviour. They can withstand the discomfort of the ambiguous situation long enough as to accommodate and generate more appropriate and flexible responses to it.

1.2. Culture's response

From a different perspective, Hofstede (13,14) argues that societies cope with uncertainty in nature through science and technology (the domain of human artefacts). We also rely on low, or formal and informal rules and norms that guide social relations, to defend ourselves against uncertainty in the behaviour of other people. Finally, religion (in the sense of revealed knowledge of the unknown) helps us to accept the limitations of life and our own limitations in this life. Ways of coping with uncertainty belong to the cultural heritage of the society and are transferred and reinforced through socialisation and education. They are reflected in the collectively held values, the life of social groups, the way organisations function, and in the governmental policy.

Science therefore is a powerful tool that human society uses in the face of the unknown and the unpredictable in nature and culture around us and within us. First of all, science provides us with *knowledge* about the nature of the phenomena we have to deal with and the lows that govern their existence across time and space. Second, science is a source of *technologies* that help us to deal with uncertainty and ambiguity. At a third place come *technical objects* that appeared as a result of the practical application of scientific knowledge and technology to the solution of different problems in human life.

On the other hand, **education** is seen as a context for socialisation in tolerance - intolerance of ambiguity. Through education young people acquire knowledge, and this knowledge impacts their images of the world, of the human being and of life in general. Through education young people gain command of technology and of the skills that are necessary for the use of technical objects. Also at school boys and girls learn those formal and informal rules and norms that help us cope with uncertainty and ambiguity in social interactions. They further adopt a system of values which supports their images of the world, the life, the people and oneself. Education realises its aim through the teaching of knowledge, the practice of skills, the formation of attitudes and by developing students' various abilities and character.

The need to avoid uncertainty is universal, but the strength of this need differs among nations, groups within nations, and individuals (13,14). Cultural differences in uncertainty avoidance may affect, for example, the predominant type of intellectual and scientific activity or schools' organisation. Scholars in high uncertainty avoidance countries would look for certainties, they have stronger theoretical orientation which is related to the need for absolute truth. In low uncertainty avoidance countries scientists would adopt a more empirical and pragmatic approach, looking for usable knowledge. Schools which function within high uncertainty avoiding context are more likely to tend towards standardisation, to have more structuring activities, written rules and ritual behaviour and to promote specialists who value expertise, are task oriented, consistent in their style, and less willing to make individual and risky decisions. Contrarily, schools operating within a low uncertainty avoiding context can be pluriform in structure and functions and would employ specialists who are pragmatic, more interpersonally oriented and flexible in their style, who are involved more in strategy than in details and are more willing to make change and assume risks (13,14).

2. Science Education and Talent Development

Within this paradigm, science education is an instrument for socialisation: young people acquire scientific knowledge, technology and technique through education. This process enables young generations to learn from their culture's experience in the ways of coping with uncertainty and ambiguities in life. Therefore, science education serves the conservation and translation of cultural traditions and human artefacts and the reproduction of scientific knowledge, technology and technique in the society.

However, science education has more than this *conservative, reproductive aspect*. Science, we said, produces knowledge, technology and technique that help people to better control their environment and their own life. Science creates something new, original and useful in the sense that it appropriately responds to human needs and solves problems. Science therefore is a creative activity and for it could successfully perform its social role, it needs creative people to get engaged in this activity. Thus science education has also to do with the identification and the development of the scientific talent in young people. This more *productive, innovative aspect* of science education suggests somewhat different array of educational goals and means.

Science education therefore needs to integrate its conservative and innovative sides. It might not always be easy to find an appropriate balance between reproductive and productive activities within the curricula: they imply the use of different type of tasks and materials, of problem solving approaches and evaluation procedures. Teachers' attitudes, skills and methods play an important role in this process.

This paper explores tolerance of ambiguity at the cross - road of science education and talent development. First, I will point out how tolerance of ambiguity relates to creativity and to the development of the creative talent. Then I will analyse the impact of education on the development of ambiguity tolerance. In conclusion I will propose my point of view on science education that promotes both talent recruitment and public understanding of the scientific research.

Empirical data from Bulgaria come from:

1 A large scale research project[2] examining the development of ambiguity tolerance in adolescents and young adults (29). In *the first study* a questionnaire for measuring ambiguity tolerance (MAT-50 of Robert Norton, (21)), adapted for use with Bulgarian population, and was administered to 392 high school children, 472 university students, and 116 18 - 25 year old working adolescents. *The second study* contrasted two groups of high-school students, identified as low (n = 51) and high (n = 55) ambiguity tolerant on the basis of their test scores in the first study. They were compared with respect to their intelligence, creative thinking abilities, temperament, anxiety, need for achievement and self-concept. *The third study* involved 303 high school students aged 14 to 19, their teachers (n = 52) and parents (n= 236). An original psychological instrument has been designed to assess the attitudes of adolescents and adults towards different ambiguity tolerant and ambiguity intolerant behaviours. The scale was used to measure the importance adolescents assign to these behaviours and to evaluate adults' encouragement of ambiguity tolerance - intolerance in adolescents (29).

2 A study of 31 boys and 75 girls, aged 14 to 19, who were enrolled in grades 9^{th} to 12^{th} of a high school specialised in applied arts. Subjects filled in questionnaires for measuring ambiguity tolerance, creative motivation and need for achievement (30).

3 A study comparing university students (29 men and 31 women) and non-university youth (25 men and 28 women) with respect to their tolerance of ambiguity, the retrospective evaluation of parents' encouragement of ambiguity tolerant - intolerant behaviours and some demographic indicators of the transition from adolescence to adulthood. This study was carried out by my student Elena Glutnikova for her BA thesis in psychology (10).

4 A study involving 35 men and 87 women aged 18 to 62 investigated the relations between ambiguity tolerance, professional preferences and professional choice in adults. This study was carried out by my student Krassimira Komneva for her BA thesis in psychology (17).

3. Ambiguity Tolerance and Creativity

Creativity is a human activity which results in the production of new, original and appropriate solution to a problem, whether it is an object, a theory or a personal or social act embedded in a particular human interaction. Theories of creativity emphasise the importance of ambiguity tolerance for the creative endeavour. On the other hand,

---

[2] This project has been supported by the Johann Jacobs Foundation.

psychological research suggest that *tolerance of ambiguity* as a characteristic of personality self-regulation in ambiguous situations builds upon individual's creative capacities. Thus ambiguity tolerance and creativity are interrelated and mutually enhance themselves.

Below I specify some of the conceptual links between ambiguity tolerance and creativity and provide empirical examples.

3.1. Tolerance of ambiguity as a resource for creativity

Creative work puts high demands on one's ability to tolerate the uncertainty induced throughout the creative process. Creative individuals need to accept the concomitant feelings of anxiety and psychological discomfort and learn to cope with. Ambiguity tolerance is thus a valuable resource for creativity (28). When, for example, the problem is not clearly defined or data does not fit together, tolerance of ambiguity operates in the construction and reconstruction of alternatives and interpretations (28). There could be also external pressures to quickly resolve ambiguities and come up with a ready solution to the problem (1,28). Some of these are contextual pressures, time limitations, others' expectations. External pressures may shorten the time for problem exploration and solution elaboration; they could prevent the individual from trying out as many alternatives as would be needed for the achievement of a truly creative outcome (1,28). Tolerance of ambiguity integrates risk taking, non-conformism, openness for experiences and humour in a dialectical balance between resistance and adaptation that characterise creativity (36).

When faced with incompleteness or unsolved problem, it is important to control the tendency to jump directly to an easy, simple and unambiguous completion of the task. Resistance to premature closure and psychological openness are beneficial to the creative process (28,35). This is recognised, for example, by designers of creative problem-solving methods: they have developed deliberate techniques to defer judgement and keep the problem open, allowing time and space for a free and flexible exploration of the incoming information (35)

Ambiguity tolerance is also important for decision making in creativity (31). Decision making is required at crucial moments in the process of generation, evaluation, selection and implementation of solutions. These are, for example, when to evaluate ideas, how to judge their originality and relevance, whether to persist or leave a stubborn problem, where to look for new possibilities, is the creative product ready to be accepted by the public. Tolerating ambiguity helps to maintain long enough an open-ended approach to the decision making and avoid premature closure on a single option (31).

However, people who are highly tolerant of ambiguity are not necessarily creative achievers. Ambiguity tolerance is just one of the individual resources required for creativity. Intellectual competencies, domain-specific knowledge and skills, creativity-relevant abilities and skills, task commitment, motivation and other personality traits and processes are also important (1,28,35,36). Tolerance for ambiguity is necessary for creativity but is not enough.

Other theorists (for example, Rogers (27), Maslow (19)) link creativity to the process of self - actualisation. In this perspective, openness to experience, lack of rigidity and defensiveness, and tolerance for ambiguities are inner conditions for creativity. The relation between self - actualisation and perceptual-cognitive processes involved in ambiguity tolerance was also supported in an empirical study with university students (7). In a similar vein, ambiguity tolerance was associated with playfulness in adults, and both related positively to a creative personality type, characterised by spontaneity, openness to experience, intuition and insight (33).

3.2. Ambiguity tolerance and motivation for creativity

An important element of individual's creativity is motivation (1,28,35,36). Motivation regulates the investment of time and efforts in problem solving, puts into action cognitive and personality resources, contributes to the development of domain-relevant creative skills and supports life-long creative performance.

My research allows to specify *the motivational role of ambiguity tolerance in creativity*. It has been found that 1) creative motivation and need for achievement are positively correlated; 2) ambiguity tolerance correlates positively with creative motivation, and 3) ambiguity tolerance doesn't correlate with need for achievement (30). Tolerance of ambiguity may empower the intrinsically motivated exploration of novel, unusual or complex stimuli and situations. In this way ambiguity tolerance contributes to the creative process. However, ambiguity tolerance is not related to the search for high standards of achievement in the results of the creative work. This conclusion is further supported by the fact that two groups - of high and low ambiguity tolerant adolescents, didn't differ in their need for achievement (29).

On the other hand, the observed positive correlation between ambiguity tolerance and creative motivation suggest that creative motivation may contribute to adolescents' tolerance of ambiguity (30). Similar pattern of relations was observed among 5-graders (20): subjects classified in the high-curiosity group were also more tolerant of ambiguity than those in the low-curiosity group. An individual who has developed creative attitudes and interests is likely to invest more time and effort in the exploration of novel, unusual or complex stimuli. In this way one may be able to avoid stereotypical perception and premature reaction to the ambiguous situation.

3.3. Shared abilities and skills

We have found that ambiguity tolerant adolescents outperformed those who were intolerant of ambiguity on both verbal and non-verbal creativity tests (29). Ambiguity tolerant students were able to generate more original and unusual ideas and solutions to open-ended verbal tasks. They also provided more inventive, imaginative and abstract titles to their pictures - titles that go beyond what can be seen. The positive association between ambiguity tolerance and creative thinking was confirmed in other studies too (15,34).

Complex relations between creativity and ambiguity tolerance emerged in a research on multicultural education (9,22). A cross-cultural simulation game was found to increase ambiguity tolerance among undergraduate students. The authors further demonstrated that creative ability and gender produce differential effect of the cross-cultural simulation game on subjects' personality (22): high creative subjects exhibited a greater shift in tolerance of ambiguity than low creative ones, in particular high creative females who scored highest in ambiguity tolerance at the post test measurement. These findings suggest that creative abilities and skills make it easier for an individual to be and to become tolerant of ambiguity.

In sum, what makes you creative in parts makes you also tolerant of ambiguity. Abilities that are relevant to creativity appear also to contribute to one's tolerance of ambiguity. These are, for example, flexibility, originality, capacity for abstraction, cognitive complexity, and curiosity. Conversely, characteristics which aim at protecting someone from encounters with ambiguity will also hinder his/her creative performance. This may happen in different ways. First, by limiting the possibility that one's curiosity, interests and motivation for creativity will be challenged. Second, by limiting one's possibilities to acquire creativity-relevant skills and knowledge. Third, by the choice of traditional paths, value conformity and rule-abiding. Intolerance of ambiguity will draw the individual towards familiarity and away from discovering. It will prevent him/her from facing the unknown and the unusual and gaining positive experience in dealing with it. Unwillingness to take risks and conservatism will limit the range of explored alternatives and of one's self-confidence (1,8,16,28,35,36).

3.4. Ambiguity tolerance and creative vocation

We have found that tolerance of ambiguity in adults is related to a preference for occupations which are characterised by high degree of ambiguity and high degree of freedom (17). In a study involving Canadian high school girls, intolerance of ambiguity at grade 12 was related to the traditionalism of the desired vocation 3 years later (26). Since the above characteristics apply to most of the creative professions, ambiguity tolerant people are more likely than intolerant ones to be inclined towards creative fields of work. Also, ambiguity tolerance seems relate to a cluster of traits and abilities that are desirable in creative professions. Some of these are openness to new ideas, exploratory orientation, cognitive complexity, capacity for abstraction, and imagination (8,16).

On the other hand, exercising a creative profession may develop one's abilities to cope with ambiguity. This suggestion is supported by a study which examined a sample of college educated women with middle-range creativity in a life-span perspective (12). Both creative potential (assessed at age 21) and creative achievement (measured at age 52) were positively associated with an increase in tolerance of ambiguity during this period. It was also found that achievement of identity (through commitment to creative work) interacted with creative potential in the prediction of creative achievement (12).

4. Education and ambiguity tolerance

We have mentioned earlier that knowledge, skills and attitudes which help people to cope with uncertainty in life have been preserved in the cultural heritage of the humanity. We also said that individuals acquire those knowledge, skills and attitudes through education. We may infer therefore that *education and formal training one has received* are important for the development of his/her ambiguity tolerance. Empirical data confirm this expectation: university students have higher tolerance of ambiguity than their age mates who are not enrolled in a university (10,29). Similarly, in adults higher educational level is associated with higher ambiguity tolerance across the life span (17). Studies with university students however showed no clear relation between university attendance and increase in tolerance of ambiguity (see, for example, (18)). From the study of creativity we also know that knowledge can inhibit the ability to deal effectively with novel and complex tasks, i.e. with ambiguous situations. This may happen, for example, when one gets rigidly stuck within traditional approaches and paradigms. Obviously, the relationship between ambiguity tolerance and one's education is not a direct one, and more research is needed in order to understand how the amount of education relates to tolerance of ambiguity.

Findings suggest that ambiguity tolerance relates to *the type of education* as well: students in arts outscore those from the business (32) and in the medical and technical universities (29). Do high ambiguity tolerant students prefer this field of study or the educational setting channels students' personality in that particular way? There is evidence that students in medicine who are tolerant of ambiguity tend to choose relatively unstructured specialities while those who are intolerant of ambiguity tend to select relatively structured fields (3). A speciality in which it is relatively easy to make diagnoses, prescribe therapies, evaluate the progress and the relations with the patients are relatively clear-cut are considered to be relatively structured. Psychiatry emerged as least structured, while obstetrics - gynaecology and surgery were among the most structured (3). Respectively, tolerance for ambiguity was found to be positively associated with preference for psychiatric career and interest in psychological factors in illness (37), but controversial findings were reported as well (5).

On the other hand, the personalised and flexible learning process, using ambiguity as a creative challenge, seems favouring ambiguity tolerance more than the group adherence to structured anonymous knowledge: the difference between the students in arts and the students in medicine is small and statistically negligible in the first year (less than 7 points) and significant at the end of their higher education cycle (more than 16 points) (29). These findings indicate that not only the fact of *being educated* bears upon ambiguity tolerance. *What you are educated in* and *the way you are educated* seem also important for the development of ambiguity tolerance.

4.1. Is tolerance of ambiguity valued at school?

One of the most powerful ways in which a culture encourages or discourages certain behaviour is the way by which teachers (and parents also) reward or punish certain personality characteristics as they develop in children and the behaviours which manifest those characteristics.

Table 1 visualises the results we have obtained in a study of ambiguity tolerance among Bulgarian high school students and their teachers (29). More than 90% of all teachers having classes with the examined students were involved, so there were science teachers in the sample too. Teachers' age ranged from 24 to 55, they had from 1 to 32 years of teaching experience in school and 25% of them were men.

The scale we used consisted of 7 behaviours that are indicative of ambiguity tolerance (AT) and 7 ambiguity intolerant (AInT) behaviours. Teachers were asked to indicate how often they encourage these behaviours in their pupils on a 4-point rating scale. Students were asked to indicate, on a 4-point rating scale, 1) how important these behaviours are for themselves, and 2) how often their teachers encourage these behaviours in them? Answers were coded in a way that greater encouragement or importance was indicated by a lower score (29).

Table 1. Means and standard deviations for teachers' self-reported encouragement of AT - AInT behaviours in students, students' perception of teachers' encouragement for AT - AInT behaviours in students, and students' evaluation of the importance of AT - AInT behaviours for themselves

Characteristics		Teachers	Teachers by students	Students
1. Puts to test him(her)self by experimenting in different situations.	AT	1.73 *(0.63)*	2.57 *(1.04)*	1.79 *(0.88)*
2. Prefers well established aesthetic values.	AInT	1.64 *(0.69)*	1.94 *(0.84)*	2.50 *(0.93)*
3. Holds definite opinion and judgements about most things.	AInT	2.08 *(0.84)*	1.77 *(0.87)*	1.79 *(0.85)*
4. Enjoys unexpected situations and surprises.	AT	1.96 *(0.77)*	2.96 *(0.93)*	1.89 *(0.93)*
5. Chooses situations with clear chances for success.	AInT	2.31 *(0.97)*	1.79 *(0.92)*	1.75 *(0.88)*
6. Prefers situations with no strict rules and no prescribed ways of doing things.	AT	2.19 *(0.91)*	2.82 *(0.96)*	2.17 *(0.99)*
7. Apt to non-traditional profession.	AT	1.96 *(0.74)*	2.85 *(0.92)*	2.53 *(1.05)*
8. Avoids risks.	AInT	2.63 *(0.77)*	2.05 *(1.02)*	2.47 *(1.10)*
9. Puts to test his (her) abilities with complex tasks which he (she) might not succeed to solve.	AT	1.75 *(0.81)*	1.98 *(0.98)*	2.10 *(1.06)*
10. Strictly follows the norms and the rules set at home and at school.	AInT	1.77 *(0.70)*	1.52 *(0.87)*	2.61 (0.94)
11. Prefers to be on the safe side.	AInT	2.19 *(0.86)*	1.65 *(0.75)*	1.97 *(0.95)*
12. Willing to participate in new endeavours and to take risk.	AT	1.75 *(0.68)*	2.59 *(0.95)*	1.99 *(0.92)*
13. Prefers the well known certain things.	AInT	2.60 *(0.72)*	1.77 *(0.82)*	2.29 *(0.95)*
14. He (she) is rather original and non-traditional in his (her) tastes and preferences.	AT	1.67 *(0.76)*	2.87 *(1.01)*	1.98 *(0.95)*

The development of ambiguity tolerance as a personality disposition goes in line with the adoption of appropriate values and beliefs. Bulgarian adolescents assign more importance to ambiguity tolerant ($M = 14.44$, $SD = 3.75$) than to ambiguity intolerant behaviours ($M = 15.42$, $SD = 3.88$) - $t = 2.73$, $p < 0.01$. While they value tolerance of ambiguity more than intolerance, certainty seeking behaviour is appreciated as well. Although preferring situations with clear chances for success, they accept to test themselves by taking risks, experimenting in different situations and participating in new endeavours. Unexpected situations and surprises are enjoyable, but it is also important to be on the safe side and to build up a definite opinion about things in life.

So do teachers: they reported encouraging ambiguity tolerance ($M = 13.12$, $SD = 2.97$) more than ambiguity intolerance ($M = 15.16$, $SD = 3.48$) - $t = 2.76$, $p < 0.01$. Teachers' self - reported degree of AT encouragement was the highest one we have observed in this study. There were no significant differences in the degree of encouragement of AT - AInT behaviours related to teachers' age and teaching experience. Male and female teachers were equally supportive to AInT behaviours but women encouraged stronger AT behaviours in their students ($t = 2.45$, $p < 0.05$), in particular their non - traditional aesthetic preferences ($t = 3.94$, $p < 0.001$) and occupational choices ($t = 2.00$, $p = 0.05$).

What is students' perception of teachers' evaluative behaviour? Adolescents think that intolerance of ambiguity (M = 12.49, SD = 3.43) is much more important than tolerance (M = 18.74, SD = 3.80) for their teachers - $t = 18.93$, $p < 0.001$. Students also see their teachers as valuing tolerance of ambiguity less ($t = 13.82$, $p < 0.001$) and intolerance of ambiguity more ($t = 9.76$, $p < 0.001$) than they do themselves. Therefore, there is a strong discrepancy between teachers' self-reported encouragement for ambiguity tolerant - intolerant behaviours and the way their reward strategies are perceived by students.

Though teachers keep on the traditional, well known practice, they see themselves as rather open to new and unusual ways of doing among their students. Their professional status may have contributed to their understanding of what promotes adolescent development in school and his/her successful after-school adaptation to work and social life. However, this seems being unnoticed on the other side: adolescents think teachers want them to avoid risks and uncertain outcomes.

Works on attitude - behaviour consistency teach us that generalised self-reported attitudes do not necessarily match one's behaviour in a particular situation. It seems understandable then that teachers' declared attitudes may differ from the way students perceive the actual behaviour of the teacher in the classroom.

Or, may be teachers are unable to identify ambiguity tolerance as it manifests itself in adolescent behaviour? If so, they wouldn't be able to offer the support they believe should be given to students. This point hadn't been examined in our study. However, research in other age groups and educational contexts suggest that teachers' evaluations could be a reliable measurement of one's ambiguity tolerance. For example, a teacher-generated index of intolerance of ambiguity obtained at age 3,5 was found to be correlated with child's personality and behavioural manifestations at ages 4,5 and 7 (11). Also, faculty members were able to evaluate students on characteristics associated with ambiguity tolerance (e.g. need for structure, openness to new ideas) six months after students' enrolment in the college,. The obtained correlation of faculty evaluations and students' scores on an ambiguity tolerance scale ($r = 0.45$, $p<0.01$) suggests that faculty were sensitive to this dimension (32).

The value adolescents assign to ambiguity tolerance - intolerance is somewhat related to their teachers' evaluative standards. This was indicated by the significant though small positive coefficients of correlation we obtained (range 0.13 - 0.41). Students who value ambiguity tolerance higher think their teachers emphasise risk avoiding and certainty seeking to a greater extent. On the other hand, students who rate intolerance of ambiguity as less important tend also to see their teachers as less supportive for ambiguity tolerant behaviours. What might be the underlying psychological mechanisms ?

It seems like students adopt values in opposition to what they perceive to be the expectations of their teachers. It could be that adult authority is seen as a source of evaluative pressure. Then this generalised adolescent perception may have an impact on their values. The observed discrepancy in the perception of teachers' reward strategies seems being part of adolescents' "subjective reality". In this sense teachers' "restrictive conservatism" serves the adolescent need for autonomy, emancipation from adults and self-determination.

In support to this suggestion was found that students' ambiguity tolerance has a significant effect on their perception of teachers' encouragement for AT ($F = 6.40$, $df = 1$, $p < 0.05$) and AInT behaviours ($F = 4.12$, $df = 1$, $p < 0.05$) - students with higher ambiguity tolerance perceived their teachers as encouraging less both AT and AInT values. It appears that more ambiguity tolerant beliefs were developed in relation with a perception of the teachers as having less evaluative power over one's own behavioural standards. Similarly, a study with Canadian adolescents has found significant negative correlation between students' scores of ambiguity tolerance and their needs for structure, i.e. the need to be offered guidance, advice, information, clarity or direction by an adult figure of authority (4). Also, ambiguity tolerance was found to significantly relate to the process of identity formation (25).

5. Conclusion: From Understanding through Acceptance to Support

Nowadays high school students will all contribute to the future of the science, either as actors or as a public. For scientists and public are both important for the development of scientific research. Scientists will confront the unknown and will apply their knowledge, skills and personality to define problems, generate ideas, test hypotheses, select criteria and elaborate solutions. Then they will work for the implementation and the acceptance of the scientific results.

On the other hand, social judgement is needed to acknowledge the creativity of the scientific results. The initial decision about what is creative and what is not is made by the creator. However, product's originality, relevance and mastery are finally judged by the targeted audience. It is a social consensual judgement that recognises the creative solution to the problem (31).

The public will provide support for the scientific research depending on the way science is perceived and understood. Society's images of science and scientists influence the very existence of this domain, its relations with the wider social system as well as the recruitment of its members, the recognition of its achievements and the application of its results (2,23,24). Nowadays negative traits can be discerned in the traditional highly positive image of the scientist. The scientist has more social roles than before, and it is not always easy to match the expectations for scientist, manager, administrator, and politician at one and the same time. The expansion of "big science" and of scientific technologies, the increased dependence of scientific investigations on substantial external funding, the invasion of mass media in the scientific work, and the general social development all contribute to the emergence of a dramatised, controversial representation of the science, where criticising and advocating, promise and concern, risks and benefits, support and resistance strive for balance (23,24).

How can scientists and public integrate contradictions and change into a new "working" model of the science? In the present situation, what attitudes should we promote, both among scientists and public, so that a space could be open for both scientific research and its acknowledgement?

Let me conclude on this note. If tolerance of ambiguity is a valuable resource for science and scientists, then science education in school should serve a double purpose. First, to select students with high tolerance of ambiguity for science and support the development of their creativity. Second, to promote tolerance of ambiguity and creativity in students' understanding of science and scientific research.

References

[1] T. Amabile, Within You, Without You: The Social Psychology of Creativity, and Beyond. In: M. Runco and R. Albert (eds.), Theories of Creativity. Sage, Newbury Park, CA, 1990, pp. 61-91.

[2] P. Bojadjieva *et al.*, Science - Life Outside the Laboratory. Bulgarian Academy of Sciences Press, Sofia, 1994.

[3] S. Budner, Intolerance of Ambiguity as a Personality Variable, *Journal of Personality* **30** (1962) 29- 50.

[4] D. Chabassol and D. Thomas, Needs for Structure, Tolerance of Ambiguity and Dogmatism in Adolescents, *Psychological Reports* **37** (1975) 507-510.

[5] B. DeForge and J. Sobal, Intolerance of Ambiguity in Students Entering Medical School, *Social Science and Medicine* **28** (1989) 869 - 874.

[6] E. Frenkel-Brunswick, Intolerance of Ambiguity as an Emotional and Perceptual Personality Variable, *Journal of Personality* **18** (1949) 108-143.

[7] P. Foxman, Tolerance for Ambiguity and Self-Actualisation, *Journal of Personality Assessment* **40** (1976) 67-72.

[8] A. Furnham and T. Ribchester, Tolerance of Ambiguity: A Review of the Concept, Its Measurement and Applications, *Current Psychology: Developmental, Learning, Personality, Social* **14** (1995) 179-199.

[9] J. Glover *et al.*, Effects of a Simulation Game upon Tolerance for Ambiguity, Dogmatism, and Risk Taking, *Journal of Social Psychology* **105** (1978) 291-296.

[10] E. Glutnikova, Tolerance of Ambiguity in Young Adulthood (18 - 25 Years), Unpublished BA Thesis in Psychology, New Bulgarian University, Sofia, 2000 (in Bulgarian).

[11] D. Harrington *et al.*, Intolerance of Ambiguity in Preschool Children: Psychometric Considerations, Behavioral Manifestations, and Parental Correlates, *Developmental Psychology* **14** (1978) 242-256.

[12] R. Helson and J. Pals, Creative Potential, Creative Achievement and Personal Growth, *Journal of Personality* **68** (2000) 1-27.

[13] G. Hofstede, Cultures'Consequences, Sage, CA, 1980.

[14] G. Hofstede, Cultures and Organizations: Software of the Mind (Bulgarian translation Teodora Mihajlowa). Klasika and Stil, Sofia, 2001.

[15] J. Houtz *et al.*, Problem Solving and Personality Characteristics Related to Differing Levels of Intelligence and Ideational Fluency, *Contemporary Educational Psychology* **5** (1980) 118-123.

[16] D. Jonassen and B. Grabowski, Handbook of Individual Differences, Learning and Instruction. Erlbaum, Hillsdale, NJ, 1993.

[17] K. Komneva, Tolerance of Ambiguity, Professional Preferences and Professional Choice, Unpublished BA Thesis in Psychology, New Bulgarian University, Sofia, 1999 (in Bulgarian).

[18] G. Kuh, Persistence of the Impact of College on Attitudes and Values, *Journal of College Student Personnel* **17** (1976) 116-122.

[19] A. Maslow, The Farther Reaches of Human Nature. Penguin Book, London, 1971.

[20] W. Maw and A. Magoon, The Curiosity Dimension of Fifth-Grade Children: A Factorial Discriminant Analysis, *Child Development* **42** (1971) 2023-2031.

[21] R. Norton, Measurement of Ambiguity Tolerance, *Journal of Personality Assessment* **39** (1975) 607-619.

[22] C. Petersen *et al.*, The Effects of a Cross - Cultural Simulation Game on Participants' Personal Characteristics, *Social Behavior and Personality* **6** (1978) 21-26.

[23] K. Petkova and P. Bojadjieva, The Image of the Scientist and Its Functions, *Public Understanding of Science* **3** (1994) 215-224.

[24] K. Petkova *et al.*, The Mass Media Image of Science Across the "Iron Curtain": Comparing Britain and

Bulgaria 1946 - 1994, *Social Studies of Science* (accepted for publication).

[25] D. Raphael. Identity Status in High School Females, *Adolescence* **13** (1978) 627-41.

[26] D. Raphael and M. Chasen, Intolerance of Ambiguity and Life Status During Early Adulthood: A Three Year Follow-Up, *Psychological Reports* **47** (1980) 388-390.

[27] C. Rogers, Toward a Theory of Creativity. In: P. Vernon (ed.), Creativity. Penguin Books, Harmondsworth, 1982, pp. 137-151.

[28] R. Sternberg and T. Lubart, Defying the Crowd: Cultivating Creativity In a Culture of Conformity. Free Press, New York, 1995.

[29] K. Stoycheva, Ambiguity Tolerance: Adolescents' Responses to Uncertainty in Life. Research Report (ERIC Document Reproduction Service No. ED 422 547), 1998.

[30] K. Stoycheva, Ambiguity Tolerance in Adolescents: Its Relations to Creativity-Relevant Traits, *7th Biennial Conference of the European Association for Research on Adolescence*, Jena, Germany, 2000.

[31] K. Stoycheva and T. Lubart, The Nature of Creative Decision Making. In: C. Allwood and M. Selart (eds.), Decision Making: Social and Creative Dimensions. Kluwer Academic Publishers, Dordrecht, 2001, pp. 15-33.

[32] M. Tatzel, Tolerance for Ambiguity in Adult College Students, *Psychological Reports* **47** (1980) 377-378.

[33] D. Tegano, Relationship of Tolerance of Ambiguity and Playfulness to Creativity. *Psychological Reports* **66** (1990) 1047 - 1056.

[34] T. Tetenbaum and J. Houtz, The Role of Affective Traits in the Creative and Problem-Solving Performance of Gifted Urban Children, *Psychology in the Schools* **15** (1978) 27-32.

[35] P. Torrance and T. Safter, Making the Creative Leap Beyond .... Creative Education Foundation Press, Buffalo, NY, 1999.

[36] K. Urban, Recent Trends in Creativity Research and Theory in Western Europe, *European Journal for High Ability* **1** (1990) 99-113.

[37] H. Walton, Personality Correlates of a Career Interest in Psychiatry, *British Journal of Psychiatry* **115** (1969) 211-219.

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Developing Programs for Science -Minded Children at the Age of 7-12

Maria HERSKOVITS
Budapest Institute for Educational Services,
H-1088 Budapest, Vas u. 8-10, Hungary

Abstract. The aim of our programs is not to prepare "little scientists", and definitely not to force them to choose their direction for life. We want to provide them the beauty and challenge of Sciences, and help them acquiring the methods for getting answers for their "whys", keeping their curiosity and enthusiasm.

1. Introduction

The age group, which is the subject of our work, is mostly not taken in consideration when speaking about Science education, and definitely is not the traditional target of it. Young children are interested in natural phenomena, but they are mostly satisfied with superficial explanations fitting to their age. At this developmental stage is not required, and most of the children are really not able to use the necessary mental operations safely. (Persistent attention, reasoning and drawing consequences in many steps, and particularly the use of abstract concepts). However highly able children show often a deep interest, they want to understand the everyday phenomena in their depth. Due the precocious development of their thinking they are able to elaborate their experiences in a more scientific way than usual in their age, if they get some proper help. The Centre for Gifted in Budapest provides this kind of programs, helping these children to maintain their interests, developing their science-minded way of thinking and preparing them to the later scientific work - whatever would be the chosen field. We would like to place our work in broader context, in the field of gifted education in Hungary.

2. Development in the field of gifted education in Hungary

The modification (1999/68) of the Act of Education (1993/79) includes some basic principles for gifted education:

paragraph 10.3:

All children have the right to receive proper education, the recognising and developing his/her abilities, interests, talents, gifts.

paragraph 48.1:

The pedagogical programs of the schools should contain some activities aiming the developing the potentials of the gifted.

The Comenius Projects (assurance of quality) have to compare the pedagogical programs with the Act of Education, and this calls the attention of the schools on the immediate task providing gifted programs. There is no consistent and national wide program of gifted education, but a lot of different elements do exist.

1. *The Hungarian Association for Gifted* was established in 1990, and its main role was and is to provide a network for all persons interested in gifted education, and to initiate by different authorities different forms in gifted education. In most of the mentioned activities the members, board -members of the Association had their decisive roles. The Association organises conferences, workshops, including the two ECHA- Conferences at Budapest and at Debrecen. The H.A.G. publishes a periodical on giftedness yearly 4-6 times. The next aim is to establish regional Centres for Gifted.

2. *The Centre for Gifted* was established in the frames of the Budapest Institute for Educational Services at 1994, providing counselling for the parents, enrichment programs for the children and teacher training.

3. *Programs at schools*: The first private school "Genius" for gifted children was established at 1990. Since then some private schools (at Szeged, Kecskemét) were established as well, and many schools offer in their pedagogical programs gifted education - however the content of these programs and methods of these can be very different. With the professional initiating and supervising of the University of Debrecen at 3 schools is a well -structured and followed gifted program for more than a decade. Many elementary and secondary schools are selective, and provide in this way a kind of gifted education (using or not using the term), and many schools run so-called gifted programs with various content and level.

4. The Ministry of Education runs and finances a *gifted program called "Arany János"* since 1999. This program aims to help the disadvantaged gifted children living in small villages (less than 5000 inhabitants). The secondary schools with highest prestige of the regions (at this time 19) provide special classes (with boarding) for these children from the age of 14. The first year was a preparatory year for teachers, when they were enrolled to additional training. The program for the pupils begins with an introductory year, mediating learning and communication skills as well, that is why we need some more time being able to evaluate the results.

5. *"Mentor" program 1.*: to involve secondary school students into university researches. The participants have yearly conferences about their researches (this Autumn 80 presentations) and the winners get the chance to participate in a summer - camp. As an extension of this program a lot of scientific research groups were established in secondary schools.

6. *"Mentor" program 2.* by chance has the same name the program of Győr, where pupils aged 10-14 of 20 schools of the town are involved in 12 different kind of afternoon enrichment programs. The program is based on 10 years work of gifted programs at school, on excessive teacher training, and the Centre for Gifted has been established in the last months.

7. At the University of Debrecen there is a *two-year postgraduate teacher-training program* (ECHA -Diploma) since 1997. The Eötvös Lóránd University at Budapest overtook this program in 1999. Beside this excessive program there has been an increasing interest for shorter (30,60, 120 hours) training on this topic, even among nursery school teachers.

8. Of course, there is continuity regarding the most traditional forms, the *national and international competitions*. The Hungarian secondary school students perform usually very well at the Science Olympic Games, and in the last years the results become more publicity and celebration.

Even from this short and imperfect list you can have the impression of the manifold and decentralised activities. The special programs for arts, music, sports, etc. are not included here at all.

3. An informal experience

There is, and during the past decades always has been a group of schools, which offered a better than average level education. These schools have mostly all the 12 levels, and are the practising place for teacher trainees, for a long time they belonged to the universities, that is why they are highly selective. The teachers themselves are considered as the top level, and the children (even in the elementary schools) are selected, mostly with a good social-economical background.

Recently I have attended a lesson of environmental studies for 8-9 years old children at one of these schools. The school is probably the strongest in the whole country. It is highly selective even at the entrance, producing the most winners of national and international competitions in Maths and Sciences. It was a demonstration, 15 teachers were sitting around. The program was excellent, the young male teacher arranged groups of four children around small tables, on the tables there were big boxes with a lot of simple devices, the children made many interesting experiments, and the conclusions were drawn mostly by the children themselves. The teacher, aiming to demonstrate that the light spreads in a straight line did the last experiment. After concluding one boy had a remark /question: he has heard that the light has in a way the nature of waves, how is this? The teacher answered a bit confused (but nicely) something like "Oh yes, I see, you have read something about, but we cannot deal with this problem".

After the lesson we discussed the experiences. The elementary school teacher was very frank, and added, he himself doesn't understand enough about physics to provide a proper explanation. One of the leading teachers (with high prestige) of the school told: "In such cases I say: you are too young to deal with such problems, you will learn about later, and then you will understand them." She continued that she finds it problematic that some children have a big verbal knowledge, without proper experiences behind. Yes, this is a problem, but how to deal with? At this school the base of the scientific thinking is taught in a proper way, but the most interested highly able children are underserved at this age, they have to wait till they are 12 and begin to learn Physics. A big question, whether they will keep their scientific interest till then. On the other hand we have to accept that an elementary school teacher is not expected to know Sciences in the depth required by these children, even if s/he has not the above mentioned rigid attitude. That is why we find extraordinary important to provide extracurricular activities, enrichment programs in Sciences at early age.

4. The Centre for Gifted at Budapest

I will speak more detailed about the field I'm most involved in, about the Centre for Gifted. It took 5 years to establish it in 1994, and now I'm the head of it for the 8th year.

As a result of many years' efforts, supported by the Budapest Municipal Local Government, in the scope of the Budapest Institute of Educational Services, based on investigations in the Institute for Psychology of the Hungarian Academy of Sciences, we have really met a demand. Ever since we have been dealing with the study of the gifted: a demand of parents for counselling, and enrichment programs for the children was present. Now - after a survey of the activity of the Centre - I am going to summarise the experiences of our enrichment programs for 6-12 years old children.

4.1. Counselling

We are available for the parents of those children whose above average abilities were obviously seen, and parents expect help in promoting their development, and/or in related practical or educational problems.

They receive professional help basically from the psychologists, and in co-operation with the pedagogical advisor there is provided counselling to choose an appropriate school, and/or supplementary programs. The majority of the children are aged from 3 to 10, that is why they are highly dependent on their parents and teachers in all respect. More than two thirds of applicants are male.

Different from the Educational Services here we see relatively many fathers. Perhaps in these families the active participation of the father in the upbringing, and his true interest in the child's intellectual development are very important. The first interview usually lasts for one and half to two hours - this is when the parents display their questions, formulate their problems, expectations, demands. In the light of this discussion new appointments are specified, and some tests are taken with the children. Finishing the process of counselling we always keep open the possibility for returning.

Our basic principles which determine the counselling process are as follows:

- our basic aim is not assessing the IQ, but to find the best ways of developing the child
- the role of the family is determinant, only taking this in consideration is possible to find the proper school and teacher
- there are not as strict frameworks within no alternatives could be found
- we always focus on the whole personality of the child, and not on certain abilities only
- problem is caused not by giftedness itself, not the surplus, but the lack of something (e.g. that of emotional maturity, social skills, supportive environment, etc.)
- reflections must be adapted according to the demands of the parents.

The main problems the parents come to us with are as follows:

In the pre-school age The most common situation is that the intellectual development of the child turns out to be quicker, more intensive than usual, than that in the elder siblings. This may bear many marks: especially good memory, outstanding logic, calculating in thousands, inquiry of unusual intensity, early spontaneous reading, or some special interest, and often with very strong will. This is met by most of the parents with some ambivalence - they are glad, but have some fears, too. Often is this associated with some 'different' behaviour of the child: speedy intellectual development is accompanied by emotional immaturity, and the parent is uncertain about how to handle these phenomena. Parents who come to us feel themselves responsible that they give the best education to their gifted child. They have frequently problems with setting borders: sometimes they are set in a very rigid way, sometimes practically not set at all.

The main questions are:

1. Is the child really highly able, even if seen by external, 'objective' eyes?
2. How high is his IQ?
3. Which is the field of the child's talent? Is it necessary to specialise him right now?
4. How can s/he develop in the best way, is not forced development harmful to him?
5. The parent wants to find a good kindergarten, or wants to change the present one
6. Is the child mature for going to school at the age of 5 or 6?
7. Discrepancy of intellectual and emotional levels of development, educational problems

At the age of schooling All problems are ranged in the question of school choice. As it was mentioned earlier, there are some schools with gifted programs, or providing a higher level of teaching. The parents feel the importance of the decision, but it is frequently overemphasised, a masque of other problems. A frequent question is whether the child just over six or even younger, should go to school yet.

In schoolchildren the most frequent problems are as follows:

1. The parent is not satisfied with the school. He thinks the teacher is not good, or the school does not properly appreciate the child, the child is bored at school.
2. The parent thinks the school gives all too little; he seeks another school for the child, or some surplus activity, or wants the child to skip a class.
3. The parent thinks the child achieves under his abilities.
4. The child has adaptation of behavioural problems in the school.

As we may see, a lot of the problems are due to the lack of meeting the special needs of the highly able children. (here we skip the adaptation problems caused by strong dissynchrony or family problems.) The children we meet at our Centre are mostly science - minded, that means, they are characterised by:

- manifold, sometimes deep interests, mostly in scientific topics
- curiosity, divergent thinking
- setting many and unusual questions
- very logical thinking, intellectual approach, unusual to their age
- a need of acquiring knowledge, to understand relationships
- knowing a lot of about different matters

4.2. Enrichment courses

The philosophy of the enrichment courses is that the highly able children should get in addition to their normal school life a challenge, which meets their intellectual needs, curiosity, providing a co-operative environment as well. Compared to the acceleration and segregation – which have their advantages too – the enrichment programs cannot harm, because the children themselves can regulate the intensity of their participation.

Our task is to provide them enrichment courses, especially in sciences, where they get a chance to deal with their intellectual problems in an emotionally safe environment. Within the enrichment frame the child learns enjoy the experience of the search for knowledge and not only the achievement.

We choose the leaders for these programs very carefully. They must be really experts in their fields, must be creative themselves, not bounded to stereotypes, prejudices, must have the ability to mediate the science for young children and must be able to provide the atmosphere of freedom and safety. In the programs happens quite frequently that secondary school teachers, or engineers, architects, etc. deal with the 7-12 years old children. The actual topic depends to great extent on the interest of the teacher, because we don't aim to provide a systematic knowledge, but let the teacher to share his/her enthusiasm. They work out an enrichment program with an emphasis on creativity and co-operation.

The aim of these courses is:

- to make the children s intellectual horizon wider, maintain and awoke curiosity
- to recompose the problems, to structure their manifold knowledge
- to teach them how to approach a question from different point of view
- to give them a chance to co-operate , help to reach emotional maturity
- to develop the children's self-confidence, ego-strength, self-criticism, persistence, the belief in their own ability to create important things

Organisation We organise these programs in the first line for our clients, but they are not exclusive. We mail the brief summary of the programs to our list, frequently join siblings, friends as well. The programs are self-supporting, the parents have to pay the costs, but the fees can be reduced when necessary.

Saturday programs Like in many other countries we have chosen the way of developing gifted providing enrichment programs for them on Saturdays. We do not take them out of their normal surroundings, they do not have to adjust to elder class-mates during everyday teaching. In addition they can take part of a course once a week, where they meet children with similar intellectual potential, thus developing his feeling and awareness towards their potentials and uniqueness. The age of the children who work together in a group covers a scope of 3-4 years. The topics are depending on the teachers' interests as well, 5-8 parallel programs are announced. The programs are organised around the most different themes, (Crafts, Chemistry in the Household, Astronomy, Experimental Physics, Playful Logic (logical and linguistic games), Beginning of the life etc. Thy have often have fantasy names, such as "Papyrus-boat" for constructing models, "Rainbow" for maths for 5-6 years old kids, or "In the Footsteps of Durell" for experiencing in nature.

I would like to speak more detailed about the course "Playful Logic", which is very popular, and illustrates well our aims and approach. The leader of this program is an engineer, member of the MENSA. The science – minded children at this age mostly are not involved in one particular field, but all of them like to use their logical abilities, and this is a good preparation for them. The main point of the method is to teach multilateral, flexible approaches to problems, ways of divergent thinking, improve logical thinking adjusting to the individual. He developed a method, using different, mostly self-made devices.

The program of the project consists of tasks for

- creative thinking – using tricky devices (e.g. Swedish wonderscrew, tangrams, etc.) to be dismounted or arranged
- playful logical exercises: exciting, strange tales (so-called logi-stories), the young Sherlock Holmes reaches the solution step-by-step, raising more and more questions
- Visual logic: optical illusion, solving contradictions with the help of strange illustrations.
- Linguistic logic: logical games with words, sentences
- Playful magic: logical solutions of "wonders". Children learn through simple, easy tricks that there is always a logical explanation behind the spectacular tricks, and often we must not believe our eyes.
- Mathematical logic. This topic does not require considerable mathematical knowledge, moreover, when solving these exercises they learn to combine logic with common sense.
- Strategic games (reversy, pylos, pick-pack, amoeba, etc): games, where luck plays no part, the winner is, who finds the winning strategy earlier. It is always important to match the partners carefully.
- Logic of the problems of everyday life: questions like why the air-wires of electric trains in zigzags, why the skyline is red, when wind approaches, etc.

You may see that the complexity and variety of the tasks develop the different functions of thinking. For these children, who have the experience to be the best in his/her environment is an extremely important experience to compete and co-operate with mates at the same level. This might be sometimes frustrating, but gives the safe feeling not being as much "different".

In all our programs the children always work in a group of maximum 6 -12 students in order to take in consideration the children's individual needs and create a warm, personal, co-operative atmosphere. A project lasts 6-10 weeks, the children have the chance to try more, different topics. The children enjoy these kind of activities, and in most of the cases the fulfilled emotional need being accepted in a relevant group helps even to manage their school problems.

Correspondent competition Not all of the interested children are able to participate at the Saturday programs: the Centre is too far away for them, they have family programs on Saturdays, etc. For them was developed this quite unique kind of enrichment programs, with very complex themes, and with the possibility to work on their own pace. The themes were Nutrition, The History of Writing, The Birds, and Triangles. We aim to make a good balance between creative approach and to teach them the methodology of research: they have to use handbooks, lexicons, possibly Internet, they get familiar with bibliography, footnotes, they make simple experiments (with protocols), observations, and present their results systematically. This sounds very seriously, but the tasks are fitting to their age, and it is always space for humour, playful approach and arts. E.g. in the theme of triangles they got familiar with the triangular composition of paintings. In the theme of nutrition they had to send us the piece of paper which became transparent after rubbed in with different foods, or had to answer the question: what is the difference between you and a tomato. (one of the most original answers: the tomato is red always, my head only, when I am angry).

The children had to send back their answers to a deadline, which turned out to be very important. They had to cope the same problem (in age 7-12!) which often characterises scientists too: when and how to finish the interesting task? They received in individual letters their results and some advises. After eight turns they met for a closing game.

We found this kind of enrichment programs as introducing in Sciences very useful and challenging in this age.

Summer camps We organise our summer -programs always around a main topic. This must be complex enough to cover courses in natural sciences, humanities and arts (the Sun - in the year of the eclipse, Light and Shadow, King Matthias - we were at the hunting area of the renaissance king, Millennium, Indians, The water, Being different, etc.) A program can be more definite about sciences, but it is necessary to develop the children's social skills, helping them to solve their socio-emotional problems, personality development - also not only their brains need nurturing.

The daily program consists from two blocs (3-3 hours) in the morning and in the afternoon. The teachers prepare the projects for 5 days, the kids can choose when applying, and for the second week they can choose another one. For the free time we offer (not-obligatory) additional programs: crafts and arts, sports, logical games, exploring something in the nature - and what the teacher is able and willing to offer, I remember, once was a very exciting competition of making and make flying paper-aeroplanes.

We found extremely important the preparation-phase with the teachers, to bring closer their (mostly implicit) concepts of giftedness, their attitudes about the necessary discipline, the aims (acquiring knowledge, promote creativity, etc.) We made at least one (possibly more) days with creativity training for them.

We never had more than 40-50 participants, and working with them in small groups, never more than 10-12 children (aged 7-14 years). Most of the children were at our Centre, for counselling and/or enrichment courses, we know them and follow their development for years. Of course, siblings, cousins friends, etc join, we have an introductory meeting and excursion, or /and we send them preparatory tasks. We don't find relevant to put an IQ-threshold, the most important is the motivational factor.

The parents have to pay the costs of the enrichment program, but our Institute provides some financial help, and the parents can apply for reduction of the tuition fees.

Sponsored by the Hungarian National Science Foundation (OTKA T029273).

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Creative Imagination in Science and Science Education

Wiesława LIMONT
14a/18 Sw. Faustyny St., PL-87 100 Torun, Poland

Abstract. Creative imagination is known to be important for every human creative activity, connected with art, with scientific and technical research as well as with social projects. Scientific discoveries, searching for a creative solution, involve, on the one hand, logical thinking processes, and, on the other hand, processes responsible for unconventional, original associations, which lead to completely new and creative ideas. Both experimental research and data from introspective studies as well as anecdotal information concerning the lives of great creators imply a very specific nature of creative imagination. Scientists came to the conclusion that creative imagination consists of visual-spatial images. Creative imagination generates new entities, unknown before. One of the ways leading towards creative solutions is metaphorical thinking; it connects elements and situations in a surprising, unexpected and yet logical way, which leads to a new understanding of a phenomenon. Another equally important characteristic of creative imagination is its dynamic character, which allows transforming images and creating completely new entities leading to new solutions. The article provides information concerning creative imagination, its use in science and the examples of its development in science education.

1. Introduction

One of the most important characteristics of the human mind which makes creative discoveries possible is transgression, which consists in the intentional crossing of borders and in going beyond what one is, what one possesses, what one knows and what one takes for granted. Transgression is connected with making discoveries, crossing the (already existing) borders and barriers. The act of transgression involves creative imagination which, on the one hand, searches for new solutions and, on the other hand, anticipates the results of scientific discoveries. Thus, creative imagination is connected with creativity and is responsible for this activity.

The notion of imagination, both in colloquial language and contemporary psychology, is ambiguous. It is usually assumed, however, that imagination is a characteristic of the human mind responsible for creating mental images and for making use of them. Mental images are internal representations of real objects, witnessed events, and situations which do not depend on real, direct perceptions. Mental images are connected with a given sensual modality, therefore they can be olfactory, gustatory, auditory, etc. For our purposes it is also essential to distinguish between creative and reproductive imagination. Reproductive imagination consists in the reproduction of objects, events and situations seen before, and is closely connected with memory. Thus, thanks to reproductive imagination it is possible to reproduce more or less precisely past experiences and sensations.

The other type of imagination, referred to as creative imagination, is connected with the transformation of the notional material. Creative imagination participates in the process of creative problem solving and is related to creativity, the process thanks to which new, original and valuable (from the social point of view) entities are produced. It is connected with scientific activity and art as well as other fields of an individual's creative activity. The special relation between creative imagination and creativity caused the scientists to investigate this human characteristic. Both experimental research and data from introspective studies as well as anecdotal information concerning the lives of great creators imply a very specific nature of creative imagination. Scientists came to the conclusion that creative imagination consists of visual-spatial images. Another characteristic of this type of imagination is that it is related to emotions, which result from the individual's profound involvement in solving a problem. Creative imagination generates new entities, unknown before. One of the ways leading towards creative solutions is metaphorical thinking; it connects elements and situations in a surprising, unexpected and yet logical way, which leads to a new understanding of a phenomenon. Another equally important characteristic of creative imagination is its dynamic character, which allows transforming images and creating completely new entities leading to new solutions. Both metaphorical thinking and the ability to transform images are essential for finding new solutions to problems. Apart from using metaphors and transformations in their search for new solutions, particularly creative scientists, artists and inventors very often resort to the technique of visualisation, which makes it much easier to find a creative solution to a problem.

2. Examples of the functioning of scientists' creative imagination

Biographic data concerning eminent creators collected by means of the introspective method often include statements which suggest that mental transformations of visual images are used in the creative process (2,3,7,12).

Einstein, well known for his imaginative skills, solved problems of theoretical physics by means of mental images. Einstein's answers to Jacques Hadamard's survey are widely known. He claimed that words or language, spoken or written, did not play any role in his process of thinking. He saw the mental units that served him as elements of thinking as signs, blurred images, which could be easily reproduced and combined. He emphasised, however, that, from the psychological point of view, this game of combinations seemed to be a characteristic of creative thinking; it was not preceded by any logical construct rendered in words or any other signs, which could be communicated to others. Einstein argued that his mental units were visual or even muscular in nature. Only in the second stage, when the already mentioned game of combinations was sufficiently developed and reproduced, did he look with much effort for conventional words or other signs (4). The formula concerning the equivalence of mass and energy theory devised by Einstein is very elegant and simple, if we consider its formal structure. Einstein claims that this result was not achieved by means of verbal deduction based on the formal mathematical apparatus but by means of intuition which involved visual images (12). James Clerk Maxwell is famous for his equation establishing the basis for the theory of electromagnetic field. Maxwell had a strong habit of creating mental images of every single problem. At the beginning of his research he visualised Faraday's lines as electrostatic tubes through which electric current flowed in the form of a liquid similar to water. The next stage involved working out a mechanical model taking into consideration magnetic attraction and electromagnetic induction. Finally, Maxwell rendered everything in a formal, elegant, symmetrical equation which was later named for him (11). Michael Faraday was a visionary in the full sense of the word. His worked involved mostly the transformation of visual images. He is famous for his representations of invisible lines of electromagnetic power in the form of thin tubes in space twisting around magnetic and electric current. As to von Helmholtz, he suggests that sensual experience and mental operations on spatial images are crucial in creative problem solving. According to von Helmholtz, memory images of pure sensory impressions can be used as elements of thought combinations. We can imagine clearly all the perspectives on mental images which we can expect from a given viewpoint, from one side or another . Von Helmholtz often described his solutions in a clear, fully developed form (13).

Many eminent creators wrote about the phenomenon of illumination: Friedrich C. Gauss and Henri Poincaré, (4) philosopher Bertrand Russel (5), authors of the theory of evolution Charles Darwin and Alfred R. Wallace (1) physicist André A. Ampère (6), inventors James Watt and Nikola Tesla (12). Contemporary physicists often claim that every discovery is a sudden, non-verbal enlightenment. Unexpectedly appearing solutions to investigated problems are discussed by Poincaré, whose gift of illumination was developed to an extraordinary degree. Jacques Hadamard also writes that words do not appear in his mind at all when he thinks about a problem, they do appear only when the new concept is conveyed to others and he has to render the mental image in a verbal form. In Hadamard's case mental images took the characteristic shape of clouds. The most striking example of concrete visual thinking and its application to problem solving can be found in the life of an inventor of Croatian origin, Nikola Tesla, who, before the actual construction of a machine, tested its model in his imagination. The model worked in his purely mental environment for a few weeks and Tesla monitored the way particular parts of the machine worked and wore out. Tesla's mental images were extremely vivid and three-dimensional; the solutions appeared suddenly in the form of kinetic-visual images as intense hallucinations (12). Mental representations were very important in the case of both Watson and his co-worker Francis Crick, who, once, waking up, saw a precise, moving image which represented the structure of the DNA cell. This vivid image appeared immediately after awakening and proved to be a thoroughly correct solution (12). Freidrich A. Kekulé experienced the images of dancing atoms. One fine summer evening the dancing atoms combined to form a molecule. Later, after numerous attempts to discover the structure of the benzene molecule, Kekulé made the historic discovery thanks to the fantastic images of dancing snakes holding their tails in their mouth (10).

There are two ways in which transformations of mental representations which are the material of creative imagination can occur: either in a continuum, with several stages of transformations, or abruptly, by generating new images with the required characteristics. Mental images have the same characteristics as perceptive images, and mental operations involving images provide visual information corresponding to the outside world. Mental processes are performed on images as if they were observed in *the mind's eye*, sometimes referred to as *the internal eye*. Scholars claim that elegance and simplicity are characteristic for mental images of creative problem solving; this phenomenon is well known in psychology of creativity. Creative solutions, irrespective of the field, are well known to have a simple and yet beautiful formal structure. After working out the formal structure of the solution, mathematicians creating a new theory are convinced that it *must be true because it is beautiful*. Creative solutions to physical and mathematical problems in the form of formulas, rules or laws have frequently simple and symmetrical formal structures and are aesthetically pleasing.

3. Creative imagination development in science education

Contemporary psychological theories emphasise the importance of mental images and imagination in the process of scientific problem solving. They are particularly significant at the stage of generating ideas to solve a problem, both when the solution is found by logical, systematic steps and when it appears unexpectedly, in the form of insight, or sudden enlightenment. Scientific discoveries, searching for a creative solution, involve, on the one hand, logical thinking processes, and, on the other hand, processes responsible for unconventional, original associations, which lead to completely new and creative ideas. The solutions found in this way can start totally new scientific fields, disciplines, or new research areas, or can provide answers to questions significant for the development of humanity. They can also answer less significant questions, which are, however, equally important from the cognitive point of view. There are numerous techniques of creative problem and task solving, but, as far as effectiveness and connection with creative imagination are concerned, the most important are the methods that use metaphorical thinking and visual images. Visual thinking, so effectively used by researchers and scientists in creative problem solving, is an ability which varies from individual to individual and depends on the stage of development. Thus, there arises the question concerning the possibilities of training and shaping this ability in science education of cognitively talented children and teenagers. Scientific data and my own research results (8,9) suggest that the development of abilities connected with mental images depends on early experience in this field and on the frequency of dealing with mental images and their transformations. The importance of notional processes and creative imagination for scientific problem solving suggests the need to implement programmes and exercises training the abilities necessary for further creative scientific work in the educational curricula for scientifically gifted children and teenagers. It is widely acknowledged that outstanding abilities in a given field do not guarantee success. A real talent requires that an individual have highly developed abilities in a specific field, but also creative abilities and a certain set of personal characteristics, which some scholars refer to as 'creative personality'.

Two stages are essential in the process of creative problem solving: the first one is connected with identifying a problem and the second one with solving it; the two stages and their quality determine the final result. Both the ability to notice a problem where others do not see it, to notice new things in a familiar situation, and the ability to find new, original solutions are connected with transgression, which consists of venturing beyond the existing, the familiar. They are also related to the capability to change focus and to shift personal sensations and thoughts from one's body to other objects, to distance oneself from the existing situation, knowledge and abilities. This process concerns both the individual, when the scientist notices new structures in old, familiar systems (the problem-finding stage) and society, when new fields and areas of activity are created (the solution-finding stage). It involves metaphorical thinking, which is basic for creative problem solving. A shift from logical, rational thinking towards intuition and emotions results in a selective choice and combination of information and leads to generating new entities based on paradoxical similarities, which, as it is commonly accepted, is the essence of a good cognitive metaphor. While trying to solve a problem, creators often identify themselves with it. This technique, supported by visualisation, allows for cognitive scientific experiments, as transgressions beyond the realm of existing knowledge become possible.

3.1. Transformation of visual images

Important skills connected with creative problem solving in science involve the ability to transform images, which leads to new, original and accurate solutions. Image transformation occurs by means of multiplication, reintegration, hyperbolisation, metamorphosis and other types of visual image transformations.

An educational curriculum devised to develop the creative imagination of gifted pupils with the use of visualisations and metaphorical thinking has been recently worked out in Poland. At the problem-finding stage pupils imagine situations and sentence structures, which enables them to perceive a familiar situation in an innovative way, from a new point of view. They also try to identify with the assignments; as I mentioned before, the ability to identify oneself with a problem, a task or problem structure greatly influences the final quality of creative solutions. At the problem-solving stage pupils use visualisation and metaphorical thinking, including the techniques allowing image transformations, which renders the thinking processes more effective and offers the possibility to find a completely new solution of a problem. Extraordinary flexibility of thinking, which is, among other things, related to image transformation abilities, makes the whole process more effective and at the same time allows dynamic transformations and searches for solutions. The assignments which most influence the development of creative imagination are those that make the pupils train the ability to transform images. Such assignments are group exercises; the instructors begin the session with a very detailed description of their mental image and the action which transforms the image into another one. The transformation of subsequent images is based on similar characteristics inherent in the two subsequent images; these features can be visual, structural or functional in nature. After the image transformation is completed by one of the participants, another one takes over up to the stage of transformation of his own mental image, etc. In this way, we obtain a series of visual images created by the participants of the meeting. Each participant memorises the created image at the moment of transformation so as to be able to present at the last stage the imagined situation in the form of a drawing, which is very important as the drawing requires making the image more precise. The described exercise aims at developing the ability to transform images, which, on the one hand, makes mental work more effective, and, on the other hand, increases the chances to work out an original and creative solution to a problem.

3.2. Visual metaphors

Other exercises important in developing scientifically gifted pupils' creative abilities are tasks connected with training metaphorical thinking and a new perception of familiar situations (a characteristic important in creative problem-solving), and with creating completely new entities resulting from the combination of disparate pieces of information, with perceiving similarities in differences and generating structures from unrelated phenomena. One of the assignments that develop creative imagination trains the ability to create figural and visual metaphors, which are important in creative problem solving. In the first stage, the participants of the meeting choose an object or phenomenon which they like, are familiar with and can say much about. The second step consists in finding a maximum number of close analogies to the selected object and choosing the one, which, according to the person producing the analogy, is the most accurate, that is the one which best describes the essence of the chosen object. The next stage involves finding a maximum number of remote 'analogies', which best demonstrate the similarity in extreme dissimilarity between the given characteristic of the chosen object and the very remote analogy. From this group the participants also select one remote analogy, which they consider the most accurate. The next stage involves combining 'forcibly' the two analogies chosen earlier (the close and remote ones) and representing such a combination in a visual form (the sign which is a synthesis of two remote pieces of information). The last stage is connected with the interpretation of each created sign by all the participants. The produced visual signs are, in fact, visual metaphors of objects chosen by the participants at the beginning of the meeting. The metaphor contains hidden information, meanings that can be revealed through the process of thorough and profound analysis and interpretation of the produced metaphorical object. Therefore, the visual metaphor produced according to the above described method makes it possible to discover information hidden in the initial object, to notice the characteristics that are not commonly associated with the object.

3.3. Autoidentification activities

As it has been mentioned before, one group of activities included exercises which made use of the autoidentification mechanism, important for human creative activity . The training sessions during which these activities were performed were prepared in accordance with a specific strategy. At the first stage the person in charge formulated the assignment; then all the students described the way they understood the assignment basing on subjective experience and feelings; at the next stage, all the students attempted to identify with a concrete object or phenomenon; next all the participants gave a precise description of what they saw using their *mind's eye*, and said how they felt being something else, identifying with a phenomenon. At the last stage students created artistic works in which they showed what they had seen and how they had felt during the identification process with a concrete object.

4. Conclusions

These and other assignments connected with training abilities and creative imagination included in cognitively gifted children's and teenagers' science education effectively shape skills and competence essential in creative task and problem solving in science. It should be emphasised that professional training focusing on a given field is not sufficient to successfully educate a truly creative scientist; it is essential to develop creative *imagination*, which, as Albert Einstein said, *is more important than knowledge*.

References

[1] W.I.B. Beveridge, Sztuka badañ naukowych, Pañstwowy Zaklad Wydawnictw Lekarskich, Warszawa, 1960

[2] A. Einstein, Autobiographical Notes. In: P. A. Schilpp (ed.) Albert Einstein: Philosopher – Scientist. Library of Living, Evanston, IL. 1946, pp. 2 –94.

[3] B. Ghiselin (ed.) The Creative Process. University of California Press, Los Angeles, 1952.

[4] J. Hadamard, Psychologia odkryæ matematycznych. Pañstwowe Wydawnictwo Naukowe, Warszawa, 1964.

[5] E. Hutchinson, How to Think Creatively, Abingdon – Cokesbury, New York, 1949.

[6] A. Koestler, The Act of Creation, Macmillan, New York, 1964.

[7] S. M. Kosslyn, Ghosts in the Mind's Machine. Creating and Using Images in the Brain. W.W. Norton and Company, New York, 1983

[8] W. Limont, Synek tyka a zdolnoœci twórcze. Eksperymentalne badania stymulowania rozwoju zdolnoœci twórczych z wykorzystaniem aktywnoœci plastycznej. Wydawnictwo Uniwersytetu Mikolaja Kopernika, Toruñ, 1994.

[9] W. Limont, Analiza wybranych mechanizmów wyobraŸni twórczej. Badania eksperymentalne. Wydawnictwo Uniwersytetu Mikolaja Kopernika, Toruñ, 1996.

[10] N. MacKenzie, Dreams and Dreaming, Aldus Books, London, 1965.

[11] J. R. Newman, James Clerk Maxwell, Scientific American, 1955, 192 (6), pp. 58 – 71.

[12] R. N. Shepard, Externalization of Mental Images and the Act of Creation. In: B. S. Randhava, W. E. Coffman (eds.), Visual Learning, Thinking and Communication. Academic Press Inc, New York, 1978, pp. 133-191.

[13] R. M. Warren, R. P. Warren, Hemholtz on Perception: Its Physiology and Development. Wiley, New York, 1968.

Science Education: Early Recruitment as a Necessity and Creative Problem Solving as Didactical Option

Ida FLEISS
World Council for Gifted and Talented Children (WCGTC) and Intertel
An der Bastion 1A, D-50679 Cologne 21, Germany

Abstract. The interest for science in gifted children can be found at a very early age, as the life-stories of famous scientists show. So recruitment already in early childhood is advisable. Some predictive criteria will be introduced for this. To gain public interest for science and for science education is a complex task. Some possible ways are introduced as they are used in Germany. At the same time, various reasons for misunderstanding or lack of interest will be discussed.

1. Introduction: Early Recruitment as a Necessity

I was a teacher in elementary schools for many years before I studied psychology. As a psychologist I am engaged in identification of gifted children and adults for many years. I will speak to you about some of my experiences.

When parents with their children come to me for diagnosis, I always ask children to tell me about their hobbies. Many of them (they are six years or older) tell me, that they like for example mathematics, chemistry, mineralogy, astrophysics, technical designing on the PC. Such interests in science arise at a very early age, already before children go to school. To further these children as early as possible is the best way to build up a pool for recruitment motivated and able students. This is a process which should be started and developed as soon as children show such interests. Experiences and research in ECHA and WCGTC confirm this approach.

The topic of this meeting is "Science Education - Talent Recruitment and Public Understanding". I want to demonstrate some strategies from my experiences and studies as well as from my personal opinion:

A look at selected biographies of people who became scientists is instructive as to their **predictive behaviors**. It becomes evident that their special interests, their eminent knowledge on special fields and their strong motivation already can be found at an early stage of age.

Some examples:

- **Francis Galton**: with 8 years he already knew the order of insects (in Latin expressions).
- **Leibniz** was capable of Latin Grammar which he studied by himself at the age of 8.
- **Marie Curie** showed very early interest in physics.
- **Einstein** read among other books at the age of 12 books about physics.
- **Bertrand Russell** was highly interested in mathematics as a small child (like Dr. Mittring was), to name only a few examples.

Analyzing the intellectual structure and the interests of gifted scientists shows some traits which have predictive value; they do not show up in normally gifted persons. Fliegler (1961) found a list of more than 20 of such characteristics, such as:

- Interest in science during preschool years
- Ability to understand abstract ideas at an early stage
- Strong imagination in scientific things
- High ability in mathematics
- Creativity in science projects
- Exceptional memory for details
- Willingness to spend long periods working alone
- Ability to perceive relationships.

> If we are able to detect such predictive behavior in young children early enough, we can lead them on the path to science by early furthering and offering them challenges and information, such as contests, project works, enrichment-seminars and similar.

2. Creative Problem Solving: INSTI Jugendclub für kreative EDV-Lösungen

In my opinion - and my experiences support it - nurturing the **creative problem solving abilities** is very important in science education. In the following I will introduce to you one example for creative problem solving and gaining public interest for science:

A youth group in Berlin, Germany, called **"INSTI Jugendclub für kreative EDV-Lösungen"**, tries to further public understanding for scientific problems and solutions by showing up in public events (such as on occasion of inventors' days) or demonstrating their outcomes in various competitions.

The group was created by an entrepreneur in the year 1992 and is scientifically guided and supported by a teacher (Master in economics and computer science). It consists of about 10 youngsters from 12 to 16 years. They meet once in every 14 days outside of school time for some hours. They study hard- and software, network and communication technology in order to know the tools for their creative projects. Youngsters are motivated to join this club because of their specific scientific interests. They can work in teams, exchange ideas, help each other - and compete against each other. They learn to design new applications and do programming for innovative problems like for instance a software for mental calculation.

Since 1997 this club is sponsored by INSTI (Innovationsstimulation) of the government. 1998 the group was selected to present their project "Mobile Computing" in a final competition. The group presented this project also on fairs and different public events and received thus a lot of public attention.

The aim of the initiator and the teacher of this club is to teach and train young people to acquire advanced knowledge in the field of creative problem solving as a base for their future study or professional training.

Creative problem solving in science education is an important method to experience structure of scientific problems. Not only the repetition of facts or the reproduction of solutions should be emphasized in science education, but primarily own individual approaches and solutions and the motivation to create new questions and problems!

3. Summary

Let me summarize:

1. There is some **predictive behavior** in early childhood for science which should be used in talent recruitment for a later science education.
2. There are many modern didactical ways for science education as e.g. project work, contests, learning by discovering. Very important in my opinion is to teach the students **creative problem solving**. Creativity is as precious for future success as intellectual potential is. Not reproduction of facts should be the aim of modern science education, but the ability to find innovative ways and creative solutions.
3. To gain **public attention**, recognition and understanding for the outcome of studies or project is a great motivator for young students. There are many occasions to meet the public (contests, presentations, press releases, publications). If motivated, the children have lots of ideas to stimulate public understanding for science.

The Implementation of the Talent Search Concept in Spain

Javier TOURÓN
Departamento de Education, Universidad de Navarra, Campus Universitario s/n, 31080 Pamplona, Espana

Marta REYERO
Center for Talented Youth, c/Tudela 16 1°D, 31003 Pamplona, Espana

Abstract. In this study, we will present some of the results we have obtained in validating the SCAT (School and College Ability Test) in Navarra, Spain. The data demonstrate the psychometric properties of this test with which for the first time in Spain, we will start to implement the Talent Search, a concept developed by Stanley. The implantation of the model will be coordinated from the Center for Talented Youth, Spain[3] (http://ctys.net), a member of the CTY International Association. The establishment of a systematic and periodic process of identification for gifted students is of extreme importance for the education system. The implementation of such as system is the only way to assure the detection of these talented youngsters in time to offer them the appropriate stimuli from as early as possible, and applying the most adequate programs. We have based our actions on the premise that all talent that is left uncultivated is lost, but to be able to cultivate it, it is first necessary to identify it.

1. Introduction

In this study, we pretend to analyze some aspects related to the validation of the School and College Ability Test (SCAT) in Spain (Navarra), and its use in the process of identifying youngsters with talent. However, first it seems necessary for us to comment on some of the motives that underlie the actual process that we have followed.

For some years now, a law has been in place to regulate non-university teaching in Spain (LOGSE, 10/1990), in which certain principles were established, some of which could serve to respond to the educational needs of the most capable students. A detailed analysis of the possibilities included within Spanish law, with respect to exceptionally talented children, can be seen in Tourón, Iriarte, Peralta y Repáraz (1). After establishing the above law, certain ordinances (i.e. Royal Decree 696/1996) appeared that specifically

[3] Founded and directed by the first author.

recognized the special educational needs that result from intellectual brilliance, and established certain measures to adequately deal with this situation. Perhaps the most generic of these is contained within the need to attend to the diversity of the pupils. Nevertheless, evolution in schools is slow and the treatment that teachers can afford to give to the most able students is not always satisfactory due to the lack of time and specific training. Moreover, it is clear that the diversity in education and the needs that generate this necessity for more diverse educational material tends, most frequently, to be generated by pupils with learning difficulties. Recently, the Institute for Quality and Evaluation of the Ministry of Education and Sports (*Instituto de Calidad y Evaluación del Ministerio de Educación Cultura y Deporte*) published a report entitled 'The state system of indicators in education' (*Sistema Estatal de Indicadores de la Educación*; INCE, 2). It is surprising to see that in the section 'Attention for the pupil with special educational needs' ("Atención al alumnado con necesidades educativas especiales"; 2, p. 66-67) there is no specific mention of pupils whose educational needs are associated with exceptional intellectual talent. The special educational needs that are contemplated are exclusively related to disabilities in one form or another, even though by law, it is understood that the exceedingly talented and capable pupils should also benefit from special attention.

In this and other countries, extreme ability is these days an educational problem of the first order that virtually passes unnoticed. Moreover, it is a problem because schools are rigidly organized in function of the ages of the students. As the pillar of their organization, this premise lacks educational foundations, as it supposes that all the children of the same age learn in a similar fashion and have the same intellectual and other needs. This is far from the reality, especially in the case of the most able pupils whose personal characteristics drive them towards a pace of learning and a thirst for knowledge that is way above the pace of their classmates and above that which the school curriculum accommodates or permits. As such, and as outlined by Van Tassel Baska (3), the education system ends up, in the best of all cases, imposing a limit to the speed of learning that is determined by the ability and competence of the average pupil. Indeed, the notion of the average pupil is an abstraction that in reality does not exist anywhere.

That the talent of some young individuals is not being looked after in an adequate manner in schools can be clearly seen when we observe that different pupils that receive the same educational programs don't obtain different results. On the one hand, given that the teaching given to pupils is adapted to the level of 'mid-range students', the levels of challenge, stimulus and difficulty, of depth and of amplitude of the materials that are taught, is way below the interests and intellectual possibilities of many children. Naturally, this situation can become more serious depending on the group in which the particular pupil finds himself, and the extent in which he/she deviates from the norm.

There are other important aspects that we would also like to consider in this introduction. It is clear that in a system where the teaching is at a poor level in terms of difficulty, it is unlikely that a pupil will standout or worse still, that they systematically obtain the best results and grades but without any effort. Thus, their abilities will go unnoticed and the most probable is that they will be labeled as a good student. However, in these circumstances, their talents and their intellectual ability will be prevented from flourishing for lack of adaptation and nurturing in their education (as much the result of what they are taught as in the way it is taught). If the capacity of the pupil is very high, some symptoms or signs will probably become obvious to the parents and teachers that some problem exists. In this case it is possible that the pupil will be correctly diagnosed (something that does not always occur), and from this point on, perhaps, and only perhaps, some specific measures will be taken to look after him.

But should we act in a different fashion? It is important to develop an education system that is preemptive and not reactive. In this respect, the system should be systematic, and directed at providing the means with which to identify what is the potential of the pupils. Once this is established, pupils can be adequately attended in terms of their educational needs, applying the measures that are seen to be opportune and that have been described in detail in the literature.

It is not possible to take seriously the viewpoint that talent is scarce, because this is not so. The prevalence of talent is easily established if one simply takes into account that the scores in any adequately standardized test fall within a normal distribution. As such, and by employing a conventional scale (IQ), we can see in figure 1 that the prevalence of talented children is indeed greater than one might imagine. Of course, such an analysis, using criteria that is simply psychometric and with a single cut off point, can produce practical problems, but it does serve as an approximation. We should consider that, depending on the actual possibilities of the moment and the particular country, around 2-3% of students should have more diverse educational opportunities made available to them than are offered in the standard curriculum. In summary, there are more gifted children in the school system than is commonly believed.

But the most important is not to define how many children, but what is more critical is to know who they are. And it is here where the process of identification comes into its own. We have set out from the premise that all talent that is not adequately cultivated can be lost. As such, we consider it crucial to establish systematic models of identification, based on solid research that will help us to develop our education systems in the most appropriate manner. It is our opinion that the principal resource for the future of a society lies in the hands of the most able individuals within that society. To talk of quality and excellence without prioritizing the dedication of particular attention to the most capable is a euphemism.

Having set out these premises, we are now ready to really attack the concept of the Talent Search, in order to later analyze the process that has been followed and assess the validity of the tool that we are using in Navarra to put this into practice.

2. The Talent Search Model[4]

As we stated in a recent paper (see 4) "One of the reasons for concentrating on the Talent Search model resides in the fact that we are dealing with a model that is prudent, simple, economical and easy to implement. Moreover, this model can be better integrated than any other within the evolution that the paradigm of gifted children has suffered with respect to the identification and development of specific talents. Furthermore, it is the model has been most extensively studied of all those that exist (over 300 articles have been published relating to the SMPY). We could add another more personal reason if it were necessary, to support those already stated, and this is that we are trying to implement this in

[4] A more detailed description can be seen in Tourón & Reyero (2001), paper from which we extracted this summary.

a systematic manner in our country. In recent years, we have completed the preparative stages by validating the SCAT in our local education area (Cf. i.e. 5)."

In 1971, Julian Stanley founded the SMPY (*Study of Mathematically Precocious Youth*) at the Johns Hopkins University in Baltimore. The principal objective of this centre was, and is, to obtain the "optimal development of intellectually talented children" (6). The SMPY works fundamentally on two fronts. On one hand, and related to the area of identification and intervention, it has set up a series of programs and services to attend to these gifted children, known as the SMPY model. This model has been evaluated and extended from the outset and contains within it the concept of *Talent Search*, directly related to the identification, which we will analyze in more detail later on. The other general aspect on which it is centered is related to the area of research. Since its conception, the SMPY has carried out a longitudinal study, similar to the classic study of Terman (1925-1959, 7) to investigate the development of the intellectually talented students, and to evaluate the impact of educational intervention during their schooling and in their professional careers (8-16).

The SMPY, according to Benbow (11), centers on the students in an individual manner and the first step is to understand that the student initially possesses mathematical abilities (discovery). This is achieved through their identification and subsequent description once a student is conscious of his capacity and distinct abilities and of their preferences (description). It is then that it becomes possible to adapt their educational program with the aim of generating an adequate learning environment, in accordance with their abilities (development). At present the SMPY is in favour of maintaining the pupil within the education system, at a level that corresponds to the abilities that they show rather than in function of their age.

In this regard, Benbow and Lubisnski (11) pointed out: "SMPY promotes primarily competence rather than age as the criterion to be used in determining who obtains access to what curricula and experiences, and at what time. The goal is to develop a combination of accelerating options, enrichment, and out-of-school opportunities (already available resources) that reflect the best possible alternative for educating a specific child and, thereby enhancing satisfaction. "This approach has been labeled curricular flexibility (11, p.159)."

The idea of identification within the SMPY is, as such, to assess the need for intervention and that the educational services that are not only adequate, but are also necessary for the development of the gifted pupil.

2.1. The process of identification within the Talent Search

We are dealing with a model of identification that maintains, as its principal objective, to select each year a great number of students that demonstrate verbal talent as well as mathematical talent, since these are considered as the pillars of all scholastic learning. The first *Talent Search* was carried out by Stanley in January 1972 (11, 17-21). Through constant research and subsequent improvements this has given rise to that which actually exists today in the USA (similar procedures have been followed out in other countries, see for instance 22, we will conduct the first Talent Search in Spain in spring 2002), with an infrastructure that extends across the whole country and that offers help to the gifted children in each state. This help has extended to other areas such as the development of educational programs or services for the parents of talented pupils. Indeed, in four universities in the USA (Northwestern University, Duke University, Denver University and Johns Hopkins University) specific centers exist from which annual talent searches are organized. Furthermore, other centers across the USA also conduct identical or analogous annual searches to those of the state. Goldstein, Stocking and Godfrey (23) offered an interesting panoramic view of the diverse *Talent Searches* that have developed from Stanley's original model.

This model of identification has two stages (see figure 1). In the first of these, that happens to coincide with the screening process, those pupils whose performance is above the 95 or 97th percentile in standard tests such as the *Iowa Test of Basic Skills, the California Achievement Test*, or other similar tests are selected. These tests are typical tests of academic achievement in the diverse subject areas, measuring as such competence and knowledge within the curriculum, and they are designed for each grade; national norms are at hand for each grade. They also reflect what it is hoped that the children of the different ages and grades should know in each subject area.

Those pupils that perform in the top 5% or 3% in these tests show - as is logical - a particularly outstanding aptitude higher than 95% or 97% of their colleagues of the same age or grade. But it is critical to be able to respond to the questions: are these children that have such a brilliant academic performance similar amongst themselves? Are their aptitudes similar? Are they children that simple do very well at school? Herein lies the key to the model. It is certain that the pupils that occupy these positions in the performance scale are brilliant, but are they all equally brilliant? The response is categorical and reflects in the clearest possible manner the problems generated by having a ceiling in testing: no, they are not equal, there are vast differences between them that are not possible to detect with this type of 'tests of level'.

In the second stage, the students selected are submitted to a diagnostic process to test their academic aptitude such as the *Scholastic Assessment Test* (SAT) or the *American College Testing Program* (ACT), but at a higher level than that to which they would correspond by age ("*out of level*"). To be more precise, the 7th grade pupils are evaluated alongside high school seniors in some of the mentioned tests. The most frequently used is the SAT, specifically the SAT I (*reasoning test*) that has mathematics section (SAT-M) and a verbal section (SAT-V).

It is important to pay special attention to the data presented in the lower part of figure 1 It is clear that the pupils that fall in the highest percentiles when tested at their level might obtain completely different scores when measured 'out of level', as actually occurs. However, about 20% of these 3% of pupils, that is to say 0.6% (around an IQ of 135) of them reach scores that are equal to or greater than those pupils about to enter university (*college-bound*; this is precisely the cut off point used). When the functioning of the model is analyzed over the years, a startling stability in this pattern of results can be seen. We cannot address this question in sufficient detail here, as such we recommend readers to analyze any of the *Talent Search* annual *reports* that are offered by the universities that have implanted this model (see also 22, for a similar experience in Ireland; 23,24; there are also more or less detailed descriptions in the quoted works of Stanley and Benbow, 15).

These data are the sufficiently expressive and are reproduced year after year in the *talent search* followed by the CTY of the Johns Hopkins University. Analogous results are also achieved with the top 3% of 5th and 6th grade pupils submitted to the PLUS test (Cf. 1995 *Young Students Talent Search Report*, CTY: Baltimore, 25). Similar evidence can also be found in the studies of Benbow (6,8), who employed a similar method with different academic ability tests. In the University of Iowa, a similar analysis was carried out but using, amongst others, the EXPLORE test, developed by the *American College Testing* (see 1,26,27).

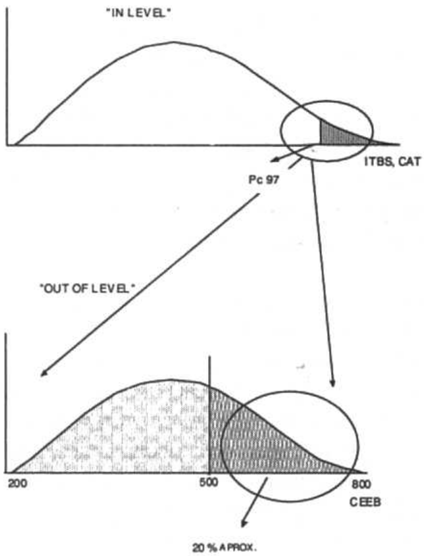


Figure 1. The Talent Search model developed by J. C. Stanley

As stated by Olszewski-Kubilius (28), the reason that the standard performance tests are not capable of evaluating precisely some of the capacities of the pupils is that they don't contain a sufficient number of items of the adequate difficulty. Therefore, as emphasized by this author the test should possess an appropriate "ceiling" in order to be able to better measure the student and thereby provide the appropriate educational provisions.

It has been stated that "through the Talent Search concept, SMPY has opened debate and dialogue in the field about viable alternatives to enrichment" (29). SMPY has restored a long tradition of emphasis on the highly gifted, begun by Terman and Hollingworth, by developing a systematic approach to finding and serving such students. SMPY also has shifted the concept of what giftedness is, from an emphasis on global ability to an emphasis on talent. SMPY, moreover, has affected school-based programs by providing a research and developmental base for content and other forms of acceleration" (29, p. 244).

But when we see how this model works over the years, we fully appreciate its extraordinary efficiency and the stability of the results. In table 1, we can see the percentage of pupils that equal or better the mean of their college-bound seniors in the SAT-M and in the SAT-V.

Table 1. Percentage of Talent Search participants (13 years old) with SAT scores equal or above the college-bound seniors score (500)

	SAT-M			SAT-V	
Year	Males	Females		Males	Females
1980	20	21	1980	24	24
1981	20	23	1981	21	18
1982	15	20	1982	19	19
1983	16	16	1983	19	17
1984	17	17	1984	19	16
1985	19	17	1985	19	15
1986	19	19	1986	19	17
1987	19	17	1987	18	17
1988	19	16	1988	15	12
1989	14	13	1989	19	18
1990	23	22	1990	16	15
1991	14	16	1991	18	19
1992	22	24	1992	18	22
1993	18	21	1993	19	22
1994	21	25	1994	18	19
1995	19	24	1995	21	22
1996*	19	25	1996	20	22
1997*	24	27	1997	24	27
1998*	25	29	1998	25	26
1999*	23	29	1999	22	24

Source: Barnett, L. *The stability of Talent Search scores over 20 years*, Manuscript in preparation. Center for Talented Youth. The Johns Hopkins University. Baltimore, USA (Reproduced by permission).

3. The validation of the SCAT (*School and College Ability Test)* in Spain

3. 1. SCAT Description

The School and College Ability Tests (SCAT) Series III represent a revision of the initial SCAT Series II originally normalized and standardized in 1966, and reviewed in 1970. These tests were developed in 1980 by the Educational Testing Service and now belong to the Center for Talented Youth of the University of Johns Hopkins.

The SCAT measures verbal and quantitative abilities of students in grades 3-12. "They are useful in comparing students or classes, comparing performance on the verbal and quantitative parts, estimating growth in abilities over time, and predicting success in related achievement areas. SCAT tests measure the accumulation of learning rather than the achievement" (30-32).

The tests exists in two forms (X and Y) with three levels of difficulty: elementary (3rd to 5th grades), intermediate (6th grade of primary education and 1st and 2nd grades of secondary education) and advanced (3rd and 4th grades of secondary education, and 1st and 2nd grades prior to University entrance, equivalent to grades 11th and 12th in the American educational system).

SCAT tests have two separately timed parts, each consisting of 50 four-option items. The part I, verbal, uses verbal analogy items to measure the student's understanding of words. The results of studies carried out by ETS indicate that verbal analogies were among the four best predictors of academic success (Cf. 32). Part II is quantitative and tests a student's understanding of fundamental number operations through quantitative comparison items. These items require the student to compare the magnitude of two mathematical quantities and make decisions concerning them. The questions place minimal emphasis on reading and require more resourcefulness and insight that traditional computational items (32).

The validation of any measurement instrument is a very complex process that implies more than a mere translation of the items. A careful review of the test content and its adaptation to the new culture is needed. For this reason, before standardizing the test, a couple of pilot studies were carried out that implied the administration of the tests to more than 3500 students, to assure the psychometric properties of all the forms and levels of the tests (for details of these studies see 33,34).

3. 2. The sampling procedure

This is a delicate process since the goodness (representativeness and size) of the sample will depend to a large part on the fitness of the norms that are obtained, naturally given that the instrument used to measure functions well.

In order to organize the sample, it is essential to determine the characteristics of the population that is of interest. In our case we shall consider two strata: school type (public/private) and grade level (3^{rd} to 12^{th}).

The process that will be detailed refers to the calculation of the desired sample size that will be duplicated in order to validate the two forms of the test in the same process, for which we have decided to work with two parallel samples. That is that we will determine a sample size that will necessitate the sampling of twice as many classrooms as would be necessary to apply a simple form of the test.

The determination of the size of the sample is carried out by dividing the theoretical distribution of the possible scores in deciles, in a way that we can determine the error that would be incorporated into the estimate of the mean value for each of them. Thus, the size of the sample would be estimated from the number of subjects that should comprise each decile at each grade level to be considered. It is also clear that this size is dependent on various parameters: the variance of the population in each decile; the number of subjects of the total population in this decile; the maximum admissible sampling error; and the confidence levels adopted.

To begin with we adopted as the maximal admissible sampling error (expressed in standard deviation units) we assume a mean value of 0.40 for each decile. Supposing that the standard deviation of each decile were 1.46 points (an estimation from other earlier studies), we would be operating with an error of 0.58 points for the estimation of the mean of each decile. If we adopt a level of confidence of 95%, this would imply a value of $z_{\alpha/2}$ = 1.96.

Given that the subjects are naturally grouped within the population (in groups of educational levels and classrooms), it was logical to think that the activity of the educational system tends to produce a certain homogeneity within each group. This homogeneity that must be taken into account to estimate the final sample size is reflected in another parameter denominated self-correlation. In practice, the subjects will be selected from a random sample by clusters, in order to respect the natural grouping of the pupils. As such, we will consider each group of the class as clusters.

Table 2. Effect of different sampling errors in the sample size

Sampling error (per decile)	Random sampling (n per decile)	Cluster sampling (n per decile)	Cluster sample size (total)
0.4 σ (0.58 points)	23.88	114.62	1146
0.5 σ (0.73 points)	15.31	73.48	735
0.68 σ (1 points)	8.29	39.79	400

As can be appreciated in table 2, and as has been shown, the effect of the error is very important in the size of the sample. It is at this point that one should determine what size of error should be considered as acceptable for the purpose at hand. In our case, it seemed reasonable to adopt an error, slightly higher, of 0.68 standard deviation units, what represent an absolute error of 1 point per decile, that which appears to be sufficiently low. This error leads to a sample size of 400 students per grade level, which means testing about 800 pupils per academic level (both forms X and Y) which is equivalent to a total sample of 8000 pupils. Exactly 7926, 4560 from public centers and 3366 from private centers, distributed between a total of 221 classrooms (clusters) in private centers and 130 (clusters) in public centers.

3. 3. Psychometric properties of the SCAT[1]

The analyses to which the results that are presented later on refer are based on the classical theoretical approach and as these are well known, we shall not enter into details here. Moreover, the tests have been calibrated following an approach based on IRT which we shall not deal with here.

The indices of difficulty (p) and discrimination (rb) have been calculated for each of the items, as has the pattern of responses to each item with the aim of determining the degree of attraction (endorsement proportion) of each of the alternatives for the groups in the highest and lowest 27%. In this way, the parameters of the items were evaluated along with the content analysis that was performed. This latter analysis proved to be particularly important, we would say essential, during the pilot studies that were undertaken.

The reliability and validity were the two global indicators of the tests that taken into account. The first was estimated by using the Cronbach coefficient α, whilst with respect to the validity, content, concurrent and predictive were analyzed to which we will not pay

[1] Form X results included here were previously included in Tourón (in press).

special attention in this paper. The results that we present pertain to both forms (X and Y) of the test.

a) Mean values of SCAT levels

In table 3, we can see the mean values of the diverse sections of the SCAT and the comparison with the results of the American versions offered in the manual.

Table 3. Mean values for the Spanish versions of the SCAT

		Form X			Form Y		
Level	Grade	Verbal	Quant.	Total	Verbal	Quant.	Total
Elementary	3°	20.2	16.8	37.0	19.4	19.08	38.4
	4°	26.1	23.3	49.3	25.1	26.6	51.6
	5°	32.9	32.9	65.8	29.5	33.3	62.8
Intermediate	6°	26.1	25.1	51.2	24.7	22.3	46.9
	1° ESO	29.3	29.7	59.0	28.7	27.4	56.0
	2° ESO	32.2	32.0	64.2	31.0	30.3	61.2
Advanced	3° ESO	26.7	27.9	54.5	27.5	27.3	54.8
	4° ESO	29.7	31.8	61.5	30.4	30.8	61.2
	1° Bach.	30.9	32.8	63.7	32.0	32.4	64.4
	2° Bach.	32.7	34.8	67.5	33.5	34.8	68.2

At the elementary level, in all the sections, the original values are higher than those in the Spanish version (form X) in both the 3° and 4° grade of primary education. In the 5°, however, the values of the Spanish version (form X) are slightly greater than those of the original. In the rest of the levels, the results of the Spanish version (form X), yield mean values a little higher in all the ages and sections, except for the verbal scores obtained in 1^{st} and 2^{nd} grades of higher secondary education, where the differences are less than 1 point. The progression of the mean values in the Spanish version is similar to the original, and the deviation of the mean values does not appear to be too important.

b) Reliability (Internal Consistency, Cronbach's α)

The last technical SCAT manual (31) offers vales for α of between 0.92 and 0.95 for the total score, of between 0.86 and 0.92 for the verbal section, and for the quantitative section of between 0.87 and 0.93. As we can see in table 4, our values fall within these ranges although closer to their lower extremes, in some cases they are a little lower. We can, as such, consider that the reliability of the Spanish version of SCAT (both forms, X and Y), expressed as internal consistency, is perfectly acceptable for the practical purpose of the measurements. The measurement errors associated to these values vary yet are less than 3 points in the verbal and quantitative sections and close to 4 points for the totals.

c) Difficulty (p) and discrimination (rb)

In table 5 and 6 we have presented the indices of difficulty and discrimination for the different sections of the SCAT and for the total scores. With respect to difficulty, it is easy to see how this decreases with the advancement of the grade levels as is logical given the increase in the age of the students. The mean difficulty for the elementary level varies between 0.40 and 0.66 for the verbal section and between 0.34 and 0.66 for the mathematics section. At the intermediate level, the range of difficulties for the verbal section was between 0.52 and 0.64 and for that of quantitative, between 0.50 and 0.64. The advanced level presented difficulties of between 0.53 and 0.65 for the verbal section and between 0.56 and 0.70 for the quantitative part. It is clear then, that the higher levels of the sets turn out to be easier for the students of the corresponding courses, although it will be of use as the 'out of level' tests for the younger students.

The mean discrimination for the sections and levels of the X form can be seen to be expressed in terms of (biserial correlations) r_b in table 5. The elementary level presents scores between 0.53 and 0.56 for the verbal section and between 0.51 and 0.56 for the quantitative part, which can be considered to be very satisfactory.

The same can be said for the scores at the intermediate level that lie between 0.49 and 0.52 for the verbal section and between 0.46 and 0.52 for the quantitative section. The values for the advanced level are somewhat less, above all in the verbal section (0.41 to 0.43), given that those for the quantitative section are 0.49 or 0.50.

The data offered by the manual for the original test for the 4^{th} to 6^{th} grades sets the levels between 0.45 and 0.54, somewhat less than those obtained by ourselves. For the higher levels, the scores represented in the original test lie between 0.44 and 0.56. As such we can see that the adapted version has a discriminative capacity similar to the original test, at some levels, higher, although in the verbal section of the advanced level it is lower, which may be influenced to some extent by the lack of difficulty of the test.

Table 4. Internal consistency (Cronbach's α) of the SCAT forms X and Y

SCAT level	Grade	Verbal X	Quant. X	Total X	Verbal Y	Quant. Y	Total Y
	3° P	0.88	0.88	0.93	0.88	0.87	0.92
Elementary	4° P	0.89	0.88	0.93	0.87	0.86	0.91
	5° P	0.89	0.88	0.93	0.88	0.86	0.92
Intermediate	6° P	0.87	0.85	0.91	0.84	0.83	0.90
	1° ESO	0.86	0.85	0.91	0.84	0.86	0.91
	2° ESO	0.86	0.88	0.92	0.88	0.87	0.91
	3° ESO	0.82	0.88	0.91	0.81	0.83	0.88
Advanced	4° ESO	0.78	0.87	0.90	0.80	0.83	0.88
	1° Bch.	0.81	0.86	0.89	0.79	0.85	0.88
	2° Bch.	0.80	0.86	0.89	0.82	0.84	0.89

Table 5. Average difficulty (p) of the SCAT (forms X and Y) verbal and quantitative sections

SCAT level	Grade	Verbal X	Quant. X	Verbal Y	Quant. Y
	3°	0.40	0.34	0.39	0.38
Elementary	4°	0.52	0.46	0.50	0.53
	5°	0.66	0.66	0.59	0.67
	6°	0.52	0.50	0.49	0.44
Intermediate	1° ESO	0.59	0.59	0.57	0.55
	2° ESO	0.64	0.64	0.62	0.61
	3° ESO	0.53	0.56	0.55	0.55
Advanced	4° ESO	0.59	0.64	0.61	0.62
	1° Bch.	0.62	0.66	0.64	0.65
	2° Bch.	0.65	0.70	0.67	0.70

Table 6. Average discrimination (r_b) of the SCAT (forms X and Y) verbal and quantitative sections

SCAT level	Grade	Verbal X	Quant. X	Verbal Y	Quant. Y
Elementary	3°	0.53	0.56	0.52	0.53
	4°	0.53	0.52	0.50	0.49
	5°	0.56	0.51	0.51	0.49
Intermediate	6°	0.49	0.46	0.44	0.45
	1° ESO	0.51	0.46	0.45	0.49
	2° ESO	0.52	0.52	0.52	0.50
Advanced	3° ESO	0.43	0.50	0.41	0.44
	4° ESO	0.41	0.50	0.41	0.46
	1° Bch.	0.44	0.49	0.40	0.48
	2° Bch.	0.41	0.50	0.45	0.47

4. Concluding Remarks

The greatest riches of a country can be found in the most capable members of its society. Indeed, to a greater extent, the future of our society is dependent on their talent, and that their capacities be fully developed and put to work for the benefit and service of the whole of mankind.

It is inescapable that in many countries, an anti-intellectual feeling has developed that looks suspiciously upon any initiative orientated toward developing talent, arguing in a puerile fashion that extra attention given to the most able provokes elitism, and is an attack against equal opportunities.

Nothing could be more further from the truth. Precisely now that the educational systems is promoting actions in order to improve the quality of education, it is necessary to strongly underline that one can't talk seriously about quality if one is not prepared to consider at the same time the promotion of excellence.

We need educational systems that offer positive guidelines and that permit us to promptly identify pupils that might require special help, and without doubt the most capable students are amongst those with such a necessity.

The endorsement of the SCAT in our country, and of the psychometric properties that it includes, will permit us to take a big step forward. Without forgetting that the SCAT and the Talent Search Concept are orientated towards a specific type of talent, related to the development of science and humanity programs (of the liberal arts curriculum we could say), but that many other talents must be nourished and developed in our countries.

In this paper, we have presented just some of the properties of the SCAT, but many others have been or are under study, such as its predictive value, it's dimensionality, etc. As such, we will shortly be embarking on a project that is based on the properties of the IRT (Item Response Theory). In this we will set out to develop a model of identification that, following the principles of the Talent Search, will optimize the time over which it is applied, and the estimates of the competence of the students.

References

[1] Tourón, J.; Peralta, F. and Repáraz, C. (1998).Diversity and School Curriculum: The response of the Spanish Educational System to the needs of Academically Highly Able Pupils. *High Ability Studies*, 9(2), 165-180.

[2] Instituto Nacional de Calidad y Evaluación (INCE) (2000). *The State System of Indicators in Education.* Madrid: Ministerio de Educación, Cultura y Deporte. Secretaría General de Educación y Formación Profesional.

[3] VanTassel-Baska, J. (1981). The great debates: For Acceleration. EC/TAG. National topical conference on the Gifted and talented Child, Orlando, Fl.

[4] Tourón J. and Reyero, M. (2001).The Talent Search Model and Acceleration: What the Research tells us?. *Educating Able Children* 5(2) pp. 21-38.

[5] Tourón, J. (2000). Expanding the Talent Search Concept in Spain: the Validation of the SCAT (School and College Ability Test). A Comparative Analysis of two Pilot Studies. Ponencia invitada en la 7th ECHA Conference: Talent for the New Millennium, Debrecen, Hungary.

[6] Benbow, C. P. (1991). Mathematically Talented Children: Can Acceleration Meet Their Educational Needs? En Colangelo, N. and Davis, G. A. *Handbook of Gifted Education.* Boston: Allyn and Bacon.

[7] Terman, L. M. and Oden, M. H. (1947). *Genetic Studies of Genius: vol. 4. The Gifted Child Grows up: Twenty Five Year's Follow up of a Superior Group* (Stanford, CA, Stanford University Press).

[8] Benbow, C. P. (1993). Meeting the Needs of Gifted Students Through Use of Acceleration. In Wang, M. C.; Maynard, C. R. and Walberg, H. J. *Handbook of Special Education: Research and Practice.* Oxford: Pergamon Press.

[9] Benbow, C. P. and Lubinski (1993). Individual Differences Amongst the Mathematically Gifted: Their Educational and Vocational Implications, *Proceedings from The 1993 Henry B. and Jocelyn Wallance National Research Symposium on Talent Development. Iowa City. The University of Iowa* (Dayton, Ohio Psychological Press).

[10] Benbow, C. P. and Lubinski, D. (Eds.) (1996). *Intellectual Talent. Psychometric and Social Issues.* Baltimore, MD The Johns Hopkins University Press.

[11] Benbow, C. P. and Lubinski, D. (1997). Intellectually Talented Children: How Can We Best Meet Their Needs? En Colangelo, N. and Davis, G. A. *Handbook of Gifted Education.* Boston: Allyn and Bacon.

[12] Stanley, J. C. (1977). Rationally of Study of Mathematically Precocious Youth (SMPY) During Its First Five Years of Promoting Educational Acceleration. In Stanley, J. C.; George, W. C. and Solano, C. H. *The Gifted and the Creative. A Fifty Year Perspective 1925-1975.* Baltimore: The Johns Hopkins University Press.

[13] Stanley, J. C. (1996). Educational Trajectories: Radical Accelerates Provide Insights. *Gifted Child Today Magazine,* 19(2), 18-21; 38-39.

[14] Stanley, J. C. (1999). SMPY's First Decade. In Colangelo, N. and Assouline, S. G. Talent Development III. Proceedings from the 1995 Henry B. and Jocelyn Wallace National Research Symposium on Talent Development. Scottsdale, Arizona: Gifted Psychology Press.

[15] Stanley, J. C. and Benbow, C. P. (1983). SMPY's First Decade: Ten Years of Posing Problems and Solving Them. *Journal of Special Education,* 17(1), 11-25.

[16] Subotnik, R. F. and Arnold, K. D. (1994). Longitudinal Study of Giftedness and Talent. In Subotnik, R. F. and Arnold, K. D. *Beyond Terman. Contemporary Longitudinal Studies of Giftedness and Talent.* Norwood, New Jersey: Ablex.

[17] Stanley, J. C.; Keating, D. P. and Fox, L. H. (Eds.). (1974). *Mathematical Talent: Discovery, Description and Development.* Baltimore: The Johns Hopkins University Press.

[18] Keating, D. P. (Eds.) (1976). *Intellectual Talent. Research and Development.* Baltimore: The Johns Hopkins University Press.

[19] Stanley, J. C; George, W. C. and Solano, C. H. (Eds.) (1977). *The Gifted and the Creative: A Fifty - Year Perspective 1925-1975.* Baltimore: The Johns Hopkins University Press.

[20] George, W. C.; Cohn, S. J. and Stanley, J. C. (Eds.) (1979). *Educating the Gifted. Acceleration and Enrichment*. Baltimore: The Johns Hopkins University Press.

[21] Benbow, C. P. and Stanley, J. C. (1983). An Eight-Year Evaluation of SMPY: What Was Learned? En Benbow, C. P. and Stanley, J. C. *Academic Precocity. Aspects of its Development*. Baltimore: The Johns Hopkins University Press.

[22] Barnett, L. B. and Gilheany, S. (1996). The CTY Talent Search: International Applicability and practice in Ireland. *High Ability Studies*, 7(2), 179-191.

[23] Goldstein, D.; Stocking, V. B. and Godfrey, J. J. (1999). What We've Learned from Talent Search Research. In Colangelo, N. and Assouline, S. G. *Talent Development III. Proceedings from the 1995 Henry B. and Jocelyn Wallace National Research Symposium on Talent Development*. Scottsdale, Arizona: Gifted Psychology Press.

[24] Barnett, L. B. and Corazza, L. (1993). Identification of Mathematical Talent and Programmatic Efforts to Facilitate Development of Talent. *European Journal for High Ability*, 4 (48-61), .

[25] Center For Talented Youth (1995). *1995 Talent Search Report* (Baltimore, CTY Publications and Resources, The Johns Hopkins University).

[26] Colangelo, N.; Assouline, S. G. and Wen-Hui Lu. (1993). Using Explore as an Above-Level Instrument in the Search for Elementary Student Talent, *Proceedings from The 1993 Henry B. and Jocelyn Wallance National Research Symposium on Talent Development. Iowa City. The University of Iowa* (Dayton, Ohio Psychology Press).

[27] Colangelo, N.; Assouline, S. G. and Lu, W. H. (1994). Using Explore as an Above-level Instrument in the Search for Elementary Student Talent. In Colangelo, N.; Assouline, S. G. and Ambroson, D. L. *Talent Development. Proceedings from the 1993 Henry B. and Jocelyn Wallace National Research Symposium on Talent Development*. Dayton, Ohio: Ohio Psychology Press.

[28] Olszewski-Kubilius, P. (1998). Talent Search: Purposes, Rationale, and Role in Gifted Education. *Journal of Secondary Gifted Education*, 9(3), 106-113.

[29] VanTassel-Baska, J. (1996). Contributions of the Talent Search Concept in Gifted Education. In Benbow, C. P. and Lubinski, D. *Intellectual Talent. Psychometric and Social Issues*. Baltimore: The Johns Hopkins University Press.

[30] Center For Talented Youth (1996). *1996 Young Talent Search Report*. (Baltimore, CTY Publications and Resources, The Johns Hopkins University).

[31] CTY (1999). *School and College Ability* Tests Manual. Technical Version. Baltimore: The Johns Hopkins University.

[32] Educational Testing Service (1972). School and College Ability Tests. SCAT series III. Manual and Technical Report. Princeton: Educational Testing Service.

[33] Tourón, J.; Gaviria, J. L.; Reyero, M.; Fernández, R. and Ramos, J. M. (2000) "La Identificación del Talento Verbal y Matemático. Validación del *School and College Ability Test* (SCAT) en Navarra." [The Identification of verbal and mathematical Talent. The validation of the SCAT in Navarra]. Pamplona: Departamento de Educación. Gobierno de Navarra.

[34] Tourón, J. (in press). School and College Ability Tests validation in Spain: Overview of the process and some results. Gifted and Talented International.

Talent Development and Cultural Diversity

David BRANDON‡, Muli DOTAN‡, Orit ZASLAVSKY* and Roza LEIKIN#
‡Center for Pre-University Education
**Department of Education in Science and Technology*
Technion – Israel Institute of Technology
Haifa, IL-32000 Israel
 # Faculty of Education
University of Haifa
Haifa, IL-32000 Israel

Abstract. The mission of the Technion Center for Pre-University Education is to attract and prepare candidates for professional undergraduate degree programs, especially in science and technology. The pre-requisite requirements for admission to these programs are based on criteria for numeracy and literacy derived from matriculation results in mathematics, physics and English as a foreign language (EFL). In the present contribution we have selected three pre-university programs for more detailed analysis and comparison. These are the TeLeM (Technion Lessons in Mathematics) program, geared primarily to junior high school students with recognized mathematical ability and proven motivation, a program for senior high school students of Ethiopian origin which includes curriculum enrichment in both mathematics and English, and a pre-university 'refresher' semester for minority students who have matriculated from Arab language high schools in Israel. Each of these three programs is designed to meet the needs of three very different communities but, even so, they all aim to reinforce the common elements of student motivation, capacity for absorbing knowledge and long-term learning. The programs differ in the age of the students (junior high school, senior high school and high school graduates) and, even more dramatically, in the students' cultural and socio-economic backgrounds. We explore some effects of the primary factors of family origins, religion and language in each case, with particular emphasis on the need to achieve adaptation to international educational standards while still maintaining strong ties to cultural and familial roots. Our main objective in this contribution is to catalyze a discussion on the advantages and limitations of cultural diversity in the recognition and development of latent talent.

1. Introduction

Ideals are all too easily hijacked by fanatics. Nevertheless, the idealism of a previous century is still a useful starting point for this contribution. About 1900, Theodor Herzl, the guiding light behind the Zionist movement for the establishment of a Jewish state, exhorted his fellow Jews with the words "Wann Ihr wollt, ist es kein Märchen": 'if you want it, it is no fairy tale'. Of course, Herzl was a child of the Austro-Hungarian Empire, and for many Zionism is not merely 'politically incorrect', but a red rag to the bull of their own convictions. Even so, Herzl's epigram summarizes the motivation behind the many programs of the Technion Center for Pre-University Education (or Pre-University Center – PUC).

The PUC started life as a program for preparing poorly qualified applicants for entry to one or other of the Technion's undergraduate degree programs. To these study programs, intended for young adults, were added a series of youth enrichment programs aimed at attracting school-age youngsters to a career in science and technology. A recognized need to identify talented children and provide them with opportunities to develop their skills led to further programs for this special group, and in 1999 this very varied menu of pre-university activities was integrated into the present PUC framework

Given the objectives of the present NATO Workshop, some definitions are in order. The academic abilities of children are commonly described under the three headings *gifted*, *talented* and *promising* (1), and the programs we will be discussing in this contribution are focused on the two latter categories, rather than highly gifted children. Moreover, we will not be concerned (except incidentally) with primary school children, but rather with those in junior and senior high school, and high school graduates. We should also, at least for the record, note that *talent* takes many forms, all of which are worthy of development: *cognitive talents* incorporating mathematical and linguistic skills, *creativity* (2) associated with the arts, innovation or invention, the *social skills* (3) required for leadership and cultural awareness, and, certainly not least, the *psychomotor talents* required for such activities as sports and dance (*'mens sana in corpore sano'*). In all cases, talent can only be turned into performance if the student has sufficient faith in himself and motivation to succeed, and if the learning environment provides the opportunities and challenges required for development and the support needed to strengthen faith and motivation.

Within the framework of the PUC, it is primarily the cognitive talents which are of concern, and the mission of the Technion Center for Pre-University Education is to prepare children, teenagers and young adults for a future career in science, engineering, technology, education, management or medicine. Although the selection of programs is very wide, they are all administered under one or other of three headings:

- Youth Enrichment
- Support for Excellence
- University Entry and Matriculation

In the present contribution we will compare three individual programs that serve populations of students from widely different age groups and cultural backgrounds. In each case the ultimate goal of all three programs is to achieve internationally acknowledged standards of numeracy and literacy while preserving traditional cultural ties and encouraging cultural awareness.

2. The programs

The three programs to be compared are summarized in Table 1 with respect to the age group involved, the target population, and the primary objectives of the program. All these programs depend for their success on full cooperation with other interested parties and these partners are also listed. For the purposes of comparison, but only as a rough guide, a limited number of factors need to be considered. These include, in addition to the age of the students, their latent scholastic ability and their cultural background. For the purposes of this contribution the term *cultural background* is limited to the origins of the student's family and their socio-economic background, their religious affiliation and their primary language (or languages) of communication.

The TeLeM (Technion Lessons in Mathematics) program is an extension of an earlier attempt to provide mathematically talented children in junior high school with an opportunity to matriculate early and enroll for undergraduate courses at the Technion before completing high school. The TeLeM program is taught by school teachers under the direction of TeLeM staff, and depends for its success on the cooperation of mathematics teachers from selected high schools who are directly involved in the program, now in its fourth year.

The Mathematics and English Program for Youth of Ethiopian Origin, now in its third year, was started at the request of the Jewish Agency, as an enrichment program intended to introduce teenagers of Ethiopian origin to modern technology. These senior high school students proved to be highly motivated and the program quickly evolved into an evening program of study aimed at improved understanding of mathematics. An English language summer camp and additional tuition for matriculation, both introduced at the request of the students, led to a redefinition of the program objective, which is now to improve the level of matriculation in mathematics and English.

The six-week Pre-University Semester for graduates of the Arab school system in Israel was introduced last summer at the request of the Technion School of Undergraduate Studies and the Technion Arab Students Union, in response to a recognized need of these minority students for both refresher and orientation courses to remove language and learning barriers to cultural adaptation on campus.

Table 1. The major characteristics of the three programs selected for comparison

Title	***Technion Lessons in Mathematics (TeLeM)***	***Mathematics and English for Youth of Ethiopian Origin***	***Pre-University Semester for Minority Students***
Age group	Primarily junior high school	Senior high school	High school graduates
Target population	Mathematically talented and promising students	The Ethiopian immigrant community	Primarily Israeli Arab students
Partners	High schools in northern Israel	The Jewish Agency	Technion School of Undergraduate Studies
Objective	Positive attitudes to mathematics and early, high level, matriculation	Promote and expand mathematical and linguistic skills	Refresher learning and adaptation to campus life

It is always helpful to consider real cases, so before describing the programs in more detail we will introduce two graduates of these programs (Fig.1).

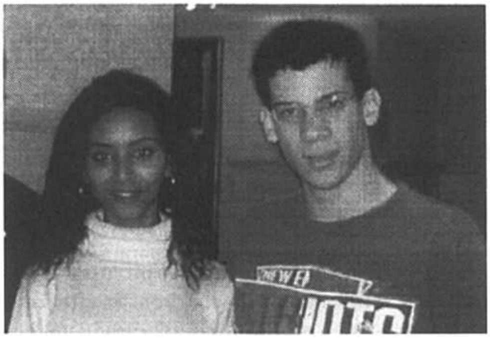


Fig. 1 Azano (Mazal) Mekonen and Ofek Birenbaum. Two of the teenagers participating in PUC programs for talented youth.

Azano (Mazal) Mekonen is now 18 years old, and was born in Ethiopia. She came to Israel when she was 6, together with her parents, grandparents, brothers and sisters. In the first stage of their journey, the family walked for many days from their village in Gondar. Azano has five brothers and sisters, and lives in Afula, in the Jezreel Valley. Her father died of cancer a few years ago. She joined our Enrichment Program when it began,, in 1999, and will matriculate at the highest level this summer. Azano says she has learnt to believe in herself and to value her talents Eventually Azano would like to have a career in one or other branch of the Health Services.

Ofek Birenbaum is 17 years old. He was born in Israel and lives in Haifa. Both his parents have careers in chemical engineering. Ofek has an older brother and a twin sister (whom he likes to describe as 'not identical'!). Ofek joined the original pilot program for TeLeM in 1996, and was selected for the first Technion Class. He matriculated in mathematics in 1999, in 10^{th} instead of 12^{th} grade, at the highest level and with an exceptionally high grade. Even before matriculating Ofek joined the Advanced Placement Program at the PUC and started to accumulate credits towards an undergraduate degree. Now in 12^{th} grade, Ofek has about half the credits needed for a degree in Computer Sciences and expects to be accepted as a full-time student to complete his undergraduate degree in 2003. His grade point average so far is in the high 90s. Ofek believes that he was rescued from 'terminal boredom' at school.

2.1 Technion Lessons in Mathematics (TeLeM)

The TeLeM program was based on an earlier, pilot program that was started with a local high school in 1996. The objective was to select mathematically talented and promising children in their final year of primary school and give them special tuition that would allow them to matriculate in mathematics at the end of Grade 10. Although this pilot program eventually expanded to accommodate classes in three additional schools there were several problems: insufficient candidates for some of the schools, a lack of suitable teaching materials and poor coordination between the different teachers.

The TeLeM concept, developed in 1998 and first implemented in 1999, integrated several activities into a single program. Special, enquiry-based, classes in mathematics were given (8 hrs/wk in place of the usual 4 or 5 hrs/wk). Enrichment classes of 3 hrs/wk, based on the development of additional material not covered by the matriculation syllabus, were given in afternoon 'mathematics clubs'. Challenging learning materials were developed following Davydov's approach (4) for several different levels of ability together with appropriate teaching manuals and under the guidance of Leonid Mednikov (5). A short training course for teachers within the project was developed and a teachers' club, meeting about once a month during the teaching year, provided a forum for the exchange of ideas on inquiry-based learning (6) and comparison of experiences between schools.

TeLeM proved successful, and some 700 students now study mathematics in the TeLeM framework, for full matriculation at the end of grade 10 (Technion classes) or grade 11 (TeLeM Classes). Some 40 teachers are actively involved in TeLeM, with another 20 to 30 having taken part in TeLeM training workshops. The workshops offered the opportunity for teachers to experience innovative approaches to learning as if they were students (7). Inter-school competitions are a useful benchmark for comparing performance between schools and this summer it is planned to hold 10 day residential summer camps covering selected topics in mathematics in a format of 6 classroom hrs/day, with each child expected to select two topics for 30 hours of instruction.

The main characteristics of TeLeM are summarized in Table 2. TeLeM has demonstrably improved children's attitudes towards mathematics and the first TeLeM graduates have now matriculated at the highest level and with flying colors. Since Technion and TeLeM classes are only for mathematics, there is no need to separate TeLeM children from their peers in other subjects. The schools taking part in TeLeM are selected primarily on the basis of their willingness to cooperate, both with the Technion Center for Pre-University Education and the other schools taking part, and use the teaching materials and teaching methods adopted for the project (8). TeLeM students come from a wide range of backgrounds and include children from the Arab, Druze and Circassian minorities. TeLeM graduates are encouraged to enroll in the PUC Advanced Placement program, accumulating credit points towards an eventual undergraduate degree. Of course, this may not be practical, either because of the physical distance of the school from the Technion, or because the priorities of the student dictate otherwise.

Table 2. The scope of the Technion Lessons in Mathematics program

Pilot Program	(1999) 4 high schools, 4 teachers, 40 students (grades 7 to 9) 4 'Technion Classes'
Current status	(2002) 9 high schools, ~40 teachers, ~700 students (grades 7 to 11), ~25 'Technion' and TeLeM classes, 13 enrichment clubs
Scope of Activities	8 hrs./week mathematics + 2 hrs. enrichment, 12 hrs. teacher-training program, teachers' club, learning and teaching materials development, competitions, 10 day live-in summer camps
Achievements	Positive attitude to mathematics. Early matriculation at the highest level. Maintaining peer group relations (TeLeM classes in parallel to regular classes)
Follow-up	Enrolment in Advanced Placement undergraduate courses
Principles	Full cooperation with schools and teachers, including financial support from both parents and the education authorities

2.2 Mathematics and English for Youth of Ethiopian Origin

In 1999, a few months before the start of the teaching year (September) the Jewish Agency approached the PUC with a request to provide an enrichment program for teenagers of Ethiopian origin who were about to start grade 11. After some negotiation, the primary objective of this program was redefined to emphasize achievement in mathematics matriculation, while retaining some elements of technological awareness through enrichment. A 4-day assessment camp was organized at the beginning of the program, based on frontal classroom exercises and the 60 candidates were assigned to one or other of four classes focused on matriculation at the 3, 4 or 5 credit point level but using TeLeM teaching materials. Before the end of the first year an open day was held for parents and guardians to explain the objectives of the program, while at the end of the first year the program was assessed by an independent body and a one week technology enrichment camp was held to introduce the candidates to the use of computers and some aspects of the engineering profession.

The results of the assessment were encouraging. There was evidence of a change in learning attitudes, with improved school grades and a better self-image, but in addition both the children and their parents reported improved support for academic study within the family. At a group discussion held at the end of the summer camp the children clearly recognized that learning was an active, not a passive, process and that the ability to matriculate in mathematics would be a key factor in opening the doors to a career in science and technology. At the same time they also pushed strongly for the PUC program to be extended to include tuition for matriculation in English.

Knowledge of English was recognized as a prerequisite for professional communication, but also as an international 'window', opening opportunities for understanding other peoples and cultures. As the time available for extra tuition during the teaching year in the PUC framework was limited, it was decided to prepare a 3-week program for a summer camp at the end of the teaching year. The 90 contact hour program was based on a daily dose of three classroom hours and three hours of guided computer-aided self-instruction. The material was prepared by Karen Eini, the originator of the Friends and Flags program (9), who has won several awards for her work on adapting the Internet to the teaching of English as an international language. Each week of the camp was prepared around a different topic (first, 'inventions', then 'travel', and finally 'music') and the teachers for the four classes eventually organized were given a short orientation course.

Both the second year of the mathematics enrichment program (at which a further 30 grade 10 children joined the previous group, now in grade 11), and the 3-week English language summer camp were judged to be a success in most respects. However, one acknowledged weakness throughout the program was lack of coordination with the teachers in the children's classes at school. In part to remedy this defect, but also in response to requests from the children for extra tuition in the schools, student tutors were recruited from the population of full-time undergraduate students at Technion. After a suitable orientation session, these tutors were sent out to the schools at least once and often twice a week, to meet with the children in the program and help them revise classroom material needed for the matriculation examination. Demand for student tutors has increased steadily.

The program is now in its third year, and the first group of 60 students will take their matriculation examinations at the end of this teaching year. Most of the group has decided to go for a higher level of matriculation (from 4 to 5 credit points, or from 3 to 4 credits). A few students did drop out of the program, but there is no doubt at all about the impact of the program on the Ethiopian immigrant community in Israel. In particular, the Jewish Agency is now funding the Weizmann Institute to undertake a similar program for children from the community living in the south of the country. At the Technion the decision has been made to widen the scope of the English language summer camp, offering a 2-week program at three different levels of competence for a total of 180 contact hours of material. Once again, Karen Eini has agreed to take responsibility for developing this revised and expanded program, which should be suitable for a wide range of EFL teaching needs.

As in the case of Table 2 and the TeLeM program, Table 3 summarizes the main features of the program for youth of Ethiopian origin.

Table 3. The scope of the program for youth of Ethiopian origin

Pilot Program	(2000) 4 teachers, 60 students (grade 10) , assessment camp, 4 evening 'Mathematics Enrichment' groups, parents' day,
Current status	(2002) 90 students (grades 10 to 12, two thirds female!), evening 'Enrichment', 3 week live-in 'English Summer Adventure' (50 students), parents' visits, school matriculation tutors
Scope of Activities	4 hrs./week mathematics enrichment and tuition,, 6 hrs/day English (3 hrs. conventional, 3 hrs self-paced Internet learning: 90 hrs total), development of teaching material
Achievements	Positive attitudes to study. Improved self-image and school grades. Parental understanding and support
Follow-up	Higher level matriculation in mathematics and English
Principles	Emphasis on self-study and self-assessment. Full coordination with community social counselors and families

2.3 Pre-University Semester for Minority Students

Among the services provided by the Dean of Students at the Technion is an office, headed by Sara Katzir, to help students deal with learning problems. In most cases these problems are fairly straightforward and only require the provision of suitable facilities for the dyslectic, the visually impaired, or students who are otherwise acknowledged to have a recognized disability. Last year this office presented a report on the status and learning problems of undergraduate students belonging to one or other of the non-Jewish, minority communities in Israel. Although loosely referred to as 'Arab students', in many cases the only thing these students have in common is their native language, Arabic, and the fact that they are for the most part graduates of the Arab language school system, which, like the religious school system, is semi-autonomous within the Ministry of Education. The term includes both Christians and Moslems, as well as Bedouin, Druze and Circassians, and, of course, both men and women.

For most of these students Hebrew is a second language and English a third language. Although many have grown up in a multicultural, city environment, the majority have grown up in small towns and villages, in a socio-economic and cultural environment that is quite different from that of the mainstream undergraduate student community at Technion.

Most Technion students are Jewish and have parents who make their living from commerce or industry, or are professionals of one kind or another.

Many changes have occurred in the profile of these students over the years. In particular they are now enrolled in a wide range of degree programs, and their community is no longer dominated by candidates for degrees in Civil Engineering. Moreover, women, both Christian and Moslem, now make up a significant proportion of the Arab student population. However, some things have not changed, and minority students at Technion remain far more likely to fail their examinations, especially in the basic, pre-requisite courses, when compared to the average student. They are also far more likely to experience crises associated with lack of self-esteem and social alienation, and they are often unable to adapt to the disciplined regime of self-study required if a student is to succeed at Technion.

In response to this report, the PUC proposed a 6-week Pre-University Semester, to be given in parallel to the Technion's Summer Semester. The proposal was accepted by the Technion, who agreed to subsidize a pilot program for the summer of 2001. The program was prepared by the PUC staff in cooperation with the Technion School of Undergraduate Studies and Daoud Bashuti, a Professor of Mathematics at Technion, himself from the Arab community, as well as with the Chairman of the Technion Arab Students' Union. The 6-week live-in program included refresher courses in matriculation mathematics and English (both at the 5 credit point level), as well as a short course on Technical Hebrew and an introductory course to familiarize the students with the computer. Several sessions were also held to discuss such topics as life on campus, self-study, cultural awareness, and preparation for examinations. Regular meetings were held with the 37 students (14 women) who registered for the course and the students completed an evaluation questionnaire at the end of the program. Although the students reaction to the course (and especially to the quality of the teaching!) was very positive, it will only be possible to determine unequivocally whether the Pre-University Semester was able to improve the learning habits of the students and reduce their learning problems when their performance at Technion is compared to students from a minority control group that did not take the program. Table 4 summarizes the main features of the Pre-University Semester.

Table 4. The scope of the pre-university semester for Arab language school

Pilot Program	(2001) 37 graduates of Arab language high schools, including 14 female students, most accepted or hoping for acceptance in undergraduate degree programs at Technion
Current status	(2002) To be recommended as a 'Refresher' program for BA/BSc candidates identified as 'at risk' in undergraduate studies
Scope of Activities	6 week live-in program, 6 hrs/day frontal refresher courses in mathematics, English and Hebrew, as well as evening sessions on self-study, cultural awareness and campus life
Achievements	Reduced undergraduate study difficulties, improved self-image and easier adaptation to multicultural life on campus
Follow-up	Monitoring of undergraduate progress
Principles	Emphasis on self-study and self-assessment. Full coordination with Technion social counselors

In the meanwhile, the decision has been made to offer the course again this coming summer in approximately the same format. Certainly, the 6-week Pre-University Semester is a great improvement on the short (40 contact hour) refresher courses in Mathematics or Physics offered routinely by the PUC. These short courses, primarily designed for students who matriculated several years previously and have been either on military service or abroad, are helpful in ensuring that students are able to cope with their pre-requisite courses, but do very little to enable them to adjust to campus life.

3. Discussion

The three programs selected have been chosen because they could not have been more different. The ability of the students, their age and their cultural background, together cover a wide spectrum of the possibilities that go to make up Israeli society. On the other hand, the Technion is a technological university dedicated to preserving international standards of higher education and therefore international standards of admittance to the various degree programs. It follows that each of the three programs chosen shares a common objective in developing the learning skills that are a pre-requisite for university admission. The question then is, to what extent does the cultural diversity presented in these three programs affect the attainment of the specified educational goals.

In Table 5 we identify three areas that might be expected to result in conflict with the educational objectives of the Technion Center for Pre-University Education as dictated by the admission requirements for undergraduate degree programs.

Table 5. Potential Problem Area Comparisons

Title	Technion Lessons in Mathematics (TeLeM)	Mathematics and English for Youth of Ethiopian Origin	Pre-University Semester for Minority Students
Origins	Mostly Israeli born, but includes Israeli Arabs, Druze and Circassians, as well as children of immigrants from many countries	Mixed, but mostly born in Ethiopia (mainly Gondar)	Israeli born, but this includes both urban centers and minority villages
Language	Hebrew in nearly all cases (home and school)	Amarhic (Tigranit) at home, Hebrew in school. English is a third language	Mainly Arabic (home and school), some Circassian. English is a third language
Religion	Majority Jewish, but also Muslim and Christian	Jewish (most often orthodox)	Muslim or Christian

The first parameter to be considered is the origins of the student. Israel is still very much an immigrant community, even though the great majority of the population was born in the country. Students registered for TeLeM are for the most part Jewish and their parents are for the most part well educated and professionally employed. Nonetheless TeLeM activities have been extended to minority schools, and many immigrant and Arab children are enrolled in the program. All TeLeM children have in common their high motivation and the mathematical talent and promise they have demonstrated.

Candidates for the second program, restricted to children from the Ethiopian community, are much more homogeneous in their origins (most came with their Amharic speaking families from small, subsistence villages in Gondar, to the north west of Ethiopia, although some came from elsewhere in Ethiopia). However, they differed enormously in their abilities (though not in their motivation), and by no means all could be called talented or promising. Their willingness to learn was a major factor in ensuring that all were able to benefit from the program, improving their mathematical and linguistic talents to the point at which matriculation at a higher level was possible.

The third program was different again, not only in that the students were older, but also in the cultural variability inherent in the minority communities in Israel. Within the Arab school system there are also large differences in the quality of the schools, with some excellent schools (several private) at one end of the scale balanced by some schools with very poor records of achievement at the other. For some of these students (especially, but not only, the Druze) cultural traditions play a major role in maintaining their self-confidence on campus. For others a combination of poor socio-economic circumstances and a history of alienation makes adaptation to campus life and a successful academic career a very remote possibility indeed.

With the exception of TeLeM, linguistic barriers to learning were identified by the students as a major problem to be overcome. Even in the TeLeM framework, many of the children come from homes where the language commonly spoken is Arabic, Amharic or Russian, rather than Hebrew, and for some of these children Hebrew and English may be third or fourth languages. An example is provided by the Circassian community, which makes a major effort to preserve Circassian at home, with Arabic the common lingua franca. Since most teaching texts for undergraduate degree courses are English language, while lectures are almost exclusively in Hebrew, all students, regardless of their background, have to attain high levels of competence in both languages. The problem may be compounded by the teaching staff, for many of whom Hebrew is a language of immigration learnt late in life. An Israeli Arab, matriculated within the Arab language school system, may be faced with lectures in Hebrew given by a Russian immigrant whose Hebrew is imperfect and heavily accented. An English language textbook may not be a particularly helpful solution to his learning problems, especially if he is unfamiliar with the technical vocabulary.

Religion, perhaps surprisingly, has proven less of a problem. The population of Israel is all too familiar with religious conflict, so perhaps our youth have to a large extent learnt to accept the heterogeneity of religious convictions as a fact of life. Christmas and Hanukah frequently overlap, and for the past several years have combined with the month of Ramadan to create a threefold celebration of monotheism. Religious fanaticism is not uncommon, but it is still limited to the convictions of a small minority and, except in some communities, makes little impact on day-to-day life. So far, our students have demonstrated a tolerance of the other's religious convictions that offers some hope for the political future.

4. Conclusions

This is clearly not a planned piece of research nor is it a statistically significant study. The number of students in the individual programs is too small. The programs 'happened to happen' and, while this is as far as possible a factual report, the conclusions can only be qualitative, based on general impressions and just one, indisputable observation. Namely, very few students dropped out of any of these three programs, and few have expressed dissatisfaction with either the objectives or the course contents.

On the contrary, and with very few exceptions, the students, the educational authorities, the families of the students and the teaching staff who have worked with the students have all agreed that each of the three programs has, in very different ways, demonstrated that well defined educational objectives can be achieved without any sacrifice of cultural roots or family ties. In summary:

• Cultural awareness and the recognition of cultural differences has proven a major factor in helping students to meet high national educational standards without losing contact with their cultural roots.

•Language problems can take many forms, but developing second or third language communication skills after puberty is a (the?) major problem.

•The support of the student's family and the full cooperation of the schools and the education authorities are essential ingredients for success.

•Good self-assessment and a student's willingness to attempt achievable goals usually make the learning experience pleasurable and rewarding.

•Neither religion nor origins seem to play a meaningful role in the programs described here – despite the Middle East conflict.

5. Acknowledgements

To the teachers whose dedication has made our work possible, to the staff of the Pre-University Center whose patience and forbearance have been sorely tried, to the Technion administration, the Israeli educational system, the local municipalities and the Jewish Agency who have all given us their trust (and occasionally their money), but most especially to the families who have entrusted their children to our care and the children themselves, without whose help we would have learnt nothing.

References

[1] Vogeli, B. R. *Special secondary schools for the mathematically and scientifically talented – an international panorama*. Colambia University: Teachers College. 1998

[2] Sternberg, R. J. (Ed.) *The nature of creativity: Contemporary psychological perspectives*. New York: Cambridge University Press. 1988

[3] Donlevy, J. G and Donlevy, T. R. New Paths to The Middle Class: Developing Social Skills Employing Positive Peer Culture. *International Journal of Instructional Media*. **22**, 1995 pp. 267-76.

[4] Davydov, V. V. *The theory of developing education*. (Teoria pazvivayushego obuchenia). Moscow: Intor. (In Russian) 1996

[5] Mednikov, L., Gurevich, I. and Leikin. R. Enrichment materials for the development of mathematical thinking. Technion, Israel (In Hebrew). 2001

[6] Battista, M. T. Fifth Graders' Enumeration of Cubes in 3D Arrays: Conceptual Progress in an Inquiry-Based Classroom. *Journal for Research in Mathematics Education*, **30**, 1999 pp. 417-448.

[7] Cooney, T. J., and Krainer, K. In-service Mathematics Teacher Education: The Importance of Listening. In A. J. Bishop et al. (Eds.), *International Handbook of Mathematics Education* (pp. 1155-1185). The Netherlands: Kluwer Academic Publishers. 1996

[8] Yerushalmy, M. *Visual Mathematics: Advanced Algebra and Analysis. A technology intensive curriculum for three years of high school pre-calculus and calculus curriculum* (in Hebrew). MACHAR 98 - special project of the Israel Ministry of Education. CET – Center of Educational Technology. 1993-1995

[9] Karen Eini http://www.friendsandflags.org/

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Future Scientists and School Attendance

Eva VONDRAKOVA
STaN-ECHA, Bellusova 1827/53, 155 00 Praha 515, Czech Republic

Abstract. Let us suppose, that some of today's scholars are future scientists. How is the school successful at the developing of their giftedness and personality? What students expect and what they receive from the education system? What problems do they have and why? Experiences of parents of gifted children, school psychologist and two excellent students – grammar school pupil and university student - how they assess their education. Can the ideal school exist at all? Let us introduce you to a not famous but a very successful school with original program, educating above all future natural scientists: The Private Grammar School „Natural School".

1. Experiences of a school psychologist

This paper summarizes experience of school psychologist, one of the four founders of previous Czechoslovak branch of ECHA. STaN - ECHA started its work at the spring 1989. From the autumn 1989 seminars for teachers and psychologists have been held regularly three to four times a year, mostly in Prague. There were also meetings of Club for clever and curious children organised once a week at the first two schoolyears of STaN – ECHA existence. Scholars 11 – 14 years old could meet interesting experts from various fields of human endeavour. These children broadened their horizons in social and natural sciences, technology and art. They developed their creativity, logical thinking, learned how to manage social relations and trained relaxation. At the beginning children were only listeners and did not ask questions similarly to their school passivity. We encouraged them to be more active and they changed their behaviour during several weeks. Looking for the lecturers for children's club we asked famous popularizators of science for cooperation as well as some of our friends as far as they were experts in any topic and were enthusiastic enough with our idea to improve children's intellectual development.

At the same time Mensa Czechoslovakia started its work. Very active Mensa (some of them both Mensa and ECHA) members decided to found the school for intellectualy gifted children. The aim was to use modern, non traditional ways of teaching for highly gifted and often problematic and nonconform students. Project of Mensa gymnasium was finished in the year 1991. It works from the schoolyear 1993/94 and after many problems things are looking up now.

Soon after the "Velvet Revolution" many other moreyears state and private gymnasiums (grammar schools for 11 – 19 or 13 – 19 years old students) were founded. One of them was at the end of this paper introduced "Natural School".

In the course of time parents started to ask the STaN – ECHA committee members for advice and help with solving their gifted children's behavioral and educational problems. That is why Club for parents began its activity in the year 1993. From that time parents of gifted children in Prague have meeting with a specialist every month during the schoolyear. Parents can exchange their experience with gifted children upbringing and consult it with the guest. Comparison of our knowledge and experience with that published by Joan Freeman and with Maria Herskovits' papers about her clubs for parents is very interesting and shows many similarities.

From that time many other parents from the whole Czech Republic found us. Below you can find typical problems their children have at school:

When our son Adam came to the 1st class, we informed his teacher that he could read fluently, and was advanced in mathematics. But the teacher told us, that differences among pupils would erase in the course of time. Now our son is excellent at mathematics and reading and is boring at school. He receives notes like: "Your son has unsuitable attitude to adults".

Father of gifted boy, who skipped the 1st class and started his school attendance straight at the 2nd class: „Stephan had no problems to become a member of class group. Despite he is the smallest in his class and nicknamed "a little nipper" by his classmates, the teacher confirms that he is well adjusted there. Problem is rather opposite: I realized (with no pleasure) that from the moment he became class group member his interest in "studying" (he was voracious reader before, looked for new information in encyclopaedias, words from foreign languages in dictionaries and so on) went down considerably. Now his main interest is to catch up on what his classmates are advanced in his eyes. He wants to measure up to them. You can imagine probably that such things are not always desirable. From a kind of restlessness and annoyance from duty to manners."

My daughter Therese was highly successful at entrance examination to the "language class". (Some primary schools in Czech Republic have classes with language-enriched curriculum from the 3rd class or mathematics-enriched curriculum from the 6th class.) I was very happy and believed (naively), that an open-minded teacher would develop creativity, critical thinking and independence of these gifted children. But it did not happen and ironically I am sorry now, that my daughter passed that examination. My complaint is that the school prefers the massive scale of information and drill to the quality of teaching. I am afraid that teachers are not interested in their pupils personalities and lower their self-confidence. My daughter used to be active at school but with time I noticed, that she gave it up, probably because of repeated neglecting of her effort by teacher.

Paradoxically, once the young school janitor caretaker took their teacher's class and managed to go over and analyse with them two of ancient Greek legends, children managed to paint a picture and write quite long notes to their notebooks, everything with ease and humour.

What my daughter needs at school is:
- More praise, encouragement of children´s activity and interest.
- To teach children how to learn.
- Friendly atmosphere at school, more informal communication, cooperative learning, not only frontal teaching.

Mother of highly gifted, active, socially well adjusted and excellent 17 years old student of grammar school told us: "When my son Jan was at his 3rd class (primary), psychologist assessed him as a highly gifted child. He had problems at school: headache because of his unused intellectual capacity, complaints that Jan was unconcentrated and drew pictures during teacher's instruction, and so on. He had problems to find a friend because he differed widely in interests from his peers.

Being a child, he was "inventor", liked systems and was fascinated by "technical elements" which he discovered in museums, trains, or even in ZOO. His interest in physics cooled off as soon as he had to learn it at school, in his classmates´ tempo. Later, as gymnasium student, he had met group of people from the math-physics faculty at the summer camp. He is interested in physics again, but only out of school."

Other 16 years old grammar school student, highly gifted, representing school successfully in all types of Olympiads complained to psychologist that he felt exploited by his school. Similarly to many his colleagues he is lacking interest of teachers not only in their students personalities but very often in the subject they are teaching. The accent is put on passive receiving of great amount of information and there are only a few teachers really enthusiastic with their subject and teaching.

As school psychologist I have met many gifted students having great problems at school. One clever and rebellious boy had excellent non problematic older brother. I asked him as gifted, successful and without behavioral problems university student to sum up what he expected from education and what he received. Jan Frolik, aged 22, at university studying medicine: Everything what a studying individuality sees around at school is based on two factors - educational system and the individuality of every single educator. Nor one or other of these guarantees a high-quality and complete development of students. Deficient educational system can be partially improved by the approach of individual educators to the students. But still the full potential of these enlightened educators cannot be developed due to many systemic obstacles or superiors in the system. Good educational system is rare and can be degraded by human mistakes, torpidity, insensitiveness or inability to improvise. Educational system has to be adjusted for improvisation. Educational system and individual attitude make the education itself, which is given to students. Let's call the education itself simply 'education'.

I would expect that the purpose of education is to develop the abilities of studying individualities, to prepare them for their lives and finally for their professions (which is not necessary in many cases). I guess no one can contradict these assumptions. The reason is that they are too general. 'To develop abilities' and 'to prepare for life' can have extremely different meanings depending on the reader. Many people (because of the education they got) are not even able to imagine most of human abilities. Many people involved in education live empty and unhappy career-based lives. Than how can we expect that they will prepare someone for life? How can we expect that they will work out good conditions for next generations to develop abilities? Sure, contemporary education is 'sufficient' for the average population, at least in the meaning of no complaints. Unfortunately, for outstanding personalities is the school experience rather devastating than developing. This is the reason I decided to involve myself in the philosophy of education.

During my studies (6 – 18 years) I was highly dissatisfied with the benefit of education to my development. After my studies I had started to analyse the circumstances of human development and I concluded my requirements for the education. I discovered many aspects of development which are neglected in common education today.

Let's talk about the development of individual qualities and preparation for life together. Both categories include (maybe surprisingly) similar features. Moreover, complete developing of the personality probably IS the best preparation for life.

Here are some important abilities which I consider desirable for a proper development of any child. Talking about abilities I mean specially the abilities of human brain, which is considered to be the most responsible structure for qualities of an individual. Gifted children have the 'disadvantage' that there is more to work with and also they are often misbalanced in various aspects, e.g. emotional lability, unsocial behavior. It is always important to remember that an extraordinary positive ability can cause misbalance and problems in other regions.

Memory is the quality which is usually developed sufficiently and the study results are predominantly based on this quality. That's the reason why most of average students don't have many problems passing the tuition knowing the subject, but in many cases without understanding the subject.

Understanding the subject corresponds to the ability of association, a proper organization of information and quick operation with the information. Association can be accomplished by interactive learning or many other special methods, which I had missed very much during my studies.

More than association and processing (most important for the scientific work) we can develop a holistic view of the world (most important for life). In this context, very helpful thing is to start the lectures with things, which are well-known and explain the relations among them. It is also necessary to work throughout the spectrum of school and scientific subjects (e.g. physics, chemistry, history) and build as many connections as possible. The separation of the ancient philosophy into many subjects is necessary in some aspects, but also dangerous (!). Paradoxically the view of the world may be easily simplified in the shadow of too many information from different subjects (e.g. I don't understand natural sciences, so I leave them alone and do my work in humane disciplines or vice versa). 'To see the purpose of the information I get' is what I really had missed.

While talking about the holistic view I want to emphasize the meaning of self-examination. By my opinion, the most important development process. You will never know and understand anything coming from outside without knowing and understanding your inside. I would suggest working on practice like meditation, drama (which sometimes appears on Czech grammar schools), psychological games or many others.

One of the most miraculous human ability is creativity. Everyone is creative, but it would be a mistake to force someone to be creative in a particular action (which happens very very often). It is possible to boost the child's development through the creativity.

The enumeration of neglected abilities could continue... To manage your feelings, emotions, affection, needs... to understand love, compassion, hate or misery. The ability to harmonize yourself, to relax tension. The ability to harmonize others, ability to communicate. There is much to do. And lack of this kind of education in schools is probably the reason of the continual quarrel among people.

Even if we know everything important about the educational process, there are still many traps on the way of developing human psyche. Above all it is necessary to take care of the motivation. Also in the context of motivation we know many useful but unused techniques. We should not also downgrade the role of friendly and pleasant environment.

Nearly each of my comments is based on my negative experience from school. In spite of that I believe that the Greek human ideal kalokagathia is reachable, and kalokagathia is, in general, what I would expect from school. And kalokagathia is what I didn't get.

Maybe the school like this under-mentioned is not so far from expectations above. Maybe because its head master was gifted child who later wanted to realize his imagine about "good school":

2. Natural School Prague, Dolní Chabry

2.1. Introduction

To give you an overall taste of our school, I use a parallel from art at the beginning. Once upon a time our teacher wrote that a monotype /a special graphic technique/ is a live organism. You usually do something with some idea of what you want to reach. However, the process of creation is so unpredictable, as you have no possibility to control it, that you only stay full of intense expectations of what may happen. This final work is always unique and it is impossible for the artist to create absolutely the same monotype once again. It is living its own life. You only helped to give birth to it.

NATURAL SCHOOL was founded as an alternative grammar school in 1993. The name is derived mainly from two items : NATURE and NATURAL ABILITIES . Its capacity is 4 grades, each includes only 1 class. The pupils who pass the entrance examination start their studies at the age of 11 and then they finish it at the age of 19 with A' levels. Sometimes older students start studying at our school as they are waiting till we open a new class, each second year. This school specialises in science, especially biology and chemistry. To become a specialist in such branches means that you need to get chance to verify your theoretical knowledge in practice. This is one of the characteristic features of our educational system.

2.2. The main features of educational system at natural school

Firstly, the most apparent sign for our school that is easily recognisable for those observing it from outside is its size.Our school is quite small. There are only 4 classes, each includes about 15 students. In total it is about 50 students. Such size brings familiar atmosphere and more personal relations than other traditional secondary schools with its size can offer. The teachers get in close contact with their students, they get to know a lot about them, often more than their own parents. On the other hand, also the students get to know a lot about their teachers. It is mutual interaction. In such size the level of anonymity, typical for overcrowded schools, is reduced to minimum. The conventional system usually brings regimentation into its classes, they seem to be like the army thanks to its strict rules. Our school with its relaxed atmosphere tries to encourage childern's natural imagination and spontaneity. However, such atmosphere of mutual confidence can be an obstacle for those who prefer authoritarian system, who are used to it and don't want to ged rid of it.

Subsequently, the size of our school modifies the whole process of education. As all the students are supposed to continue their studies at Universities, the educational system tries to prepare them for such type of work, where they will have to do a lot of work on their own. In contrast to traditional secondary schools which focus on knowledge and try to cram children's heads with the highest amount of facts, our school tries to use all the opportunities to develop their whole personality. The teacher's role is not only to be the main source of knowledge in the classroom, but to encourage the students to develop their own natural abilities in their own way. To stimulate them to develop themselves. That is why we have decided to create this alternative way of teaching and learning which combines three fields of activities : internal, external and extra school activities. The internal field is connected with the building as a base-camp and is the most similar to classical model of education, where the students should absorb theoretical knowledge. During the school year we regularly go out at least six times for several days. For example, our school always starts with a week's hiking trip to the mountains. These trips are usually focused on different activities. The students get the chance to link their theoretical knowledge with practical experience, and so consolidate their knowledge. Futhermore, they learn the first aid, do drama, or even make a school movie at that external activities. The highlight of that series is the expedition, which lasts for two weeks. The extra school activities demand less time than the external trips, but they cover contemporary challenges of our city and its environment. For example, the students take part in various actions, demonstrations, meetings and cultural events, where they present their own opinions about discussed problems.

The next significant feature of our school is the "conditional system". It is system of grades and marks which are completely different from what exits at all secondary schools in the Czech Republic. At the beginning of the term everyone gets a list of the so called conditions and the number which is necessary to complete by 20th May of the relevant term. The conditions are divided into groups : A, B, C. Some of the conditions are compulsory and need to be completed in a group, others are optional. It is students' decision whether they do some of the conditions from the group A, involving themes taught during lessons, from the group B, concerning practical exercises or from the group C which are separate themes expanding the framework of the tuition.

The students who complete the conditions by 20th May are supposed to participate on some of the researches in the expedition. According to their interest and attitudes to scientific branches they choose a group which deals with a particular matter. There are groups such as biological (botanical), geological, hydrobiological, historical and many others. After a week's preparation we all go for a two week terrain research in the particular groups they have decided to take part in. After all work has been done, they make a collection of their reports and then they present their outcomes and summaries at the Faculty of Nature Sciences of Charles University.

Another characteristic feature for functioning of our school is the autonomy. Each of the students and teachers has the opportunity and right to contribute to the cycle of activities and every-day functioning of the school with their own ideas. Each group has its own leader (captain) and all these leaders get together twice a week at a special meeting , where they deal with the problems either positive or negative. Another component of the the autonomy is the "collective council" which doesn't only solve key problems, but is also a way of beginning a day by singing or reading a book.

2.3. The opinions of some students about their school

"The school I attend is a specific one. Its system is so alternative that the students who would not pass the common system of a grammar school are able to get good grades and study successfully. The quality of that school is not lower than the other grammar schools have. The school system is based on conditions which are a group of themes that we learn. A-group is filled with themes that we learn at school and the other groups are additional. There are rather helpful aids such as some themes, games, etc. The best advantage of this system is that there are only 4 deadlines of fulfiling the conditions. The students are able to chose when and what do they want to fulfil. For example, our teacher has taught us the system of mammals and if I don't have time now, I don't have to take the exam. I can delay it." Michael, 19

"My school is special, but good. In our school there are not marks, but we have to do special tasks that are determined for all the months. In school I like geography, history and arts and our trips or tracks in countryside, especially our "expeditions" at the end of the year. I don't mind biology, chemistry and Czech language. I don't like travelling to school. Every day I must get up at half past five. I spend too much time on the way to or from our school." Lucas, 13

2. 3. Summary

The whole system of our school is in its compexity built in such a way to reinforce children's sense for responsibility through various activities. They should be aware the fact they are responsible for their own lives, as well as the whole community they belong to. The teachers are those who help them to achieve their full potential. It is not enough for the students to know the subject, to have the knowledge, but they should develop their whole personality. It consists of not only brain and mind, but also the feelings. The teacher should function here just only as a starting impulse on the way of creation " unique monotypes", not uniform stereotypes.

References

[1] J.Freeman, Educating the Very Able, Ofsted, London 1998

[2] J.Freeman, Gifted Children Grown Up, David Fulton Publishers, London 2001

[3] J.Freeman, P.Span and H.Wagner (eds), Actualizing Talent, Cassell, London 1995

[4] D. Montgomery, Educating the Able, Cassell, London 1996

[5] K.Tirri, How Finland Meets the Needs of Gifted and Talented Pupils, in: High Ability Studies 8/2, ECHA, December 1997

[6] P.Young and C.Tyre, Gifted or Able? Realizing Children's Potential, Open University Press 1992

[7] B.Kerr, Smart Girls Two: A New Psychology of Girls, Women, and Giftedness, Ohio Psychology Press 1994

[8] National Networks for Gifted Children, International Conference Proceedings, Rovinj 2000, Open Society Institute, Croatia,

[9] M.Csikszentmihalyi, Flow (The Psychology of Optimal Experience), 1990 (Czech Translation, NLN Prague 1996)

[10] R.P.Feynman and R.Leighton, „Surely You're Joking, Mr. Feynman!" Adventures of a Curious Character, W.W.Norton and Company, New York 1985

[11] G.Feynman and R.Leighton, What do you care what other people think?: further adventures of a curious character., Unwin Human Limited, London 1989

[12] http://www.osf.cz/prirodni.skola/ website of „Natural School" (in Czech)

Session III

Extracurricular Science Education

This page intentionally left blank

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

The Ashoka Innovative Learning Initiative

Laura AX and Barbara ERŐS
Ashoka Hungary, Kmety Gy. str. 15. I. 2.,
Budapest 1063, Hungary

Abstract. Ashoka's mission is to develop the profession of social entrepreneurship around the world. Since 1981, Ashoka has invested in over 1200 leading social entrepreneurs ("Ashoka Fellows") in 42 countries around the world. These Ashoka Fellows are working in every area of social need, including education, the environment, health care, economic development, housing and law reform. To draw on the experiences of these powerful innovators, Ashoka launched the Global Initiatives in 1999. The Global Initiatives are identifying and documenting the most successful ideas and strategies Ashoka Fellows are using to bring about broad, systemic social change, and to disseminate these ideas worldwide. The first Global Initiative launched was the Innovative Learning Initiative (ILI) due to the fact that almost a quarter of all Ashoka Fellows are working in the areas of education and/or youth development. The present paper summarizes the principles of this initiative and gives examples of these principles citing the work of several Ashoka Fellows.

1. Ashoka's Mission

Ashoka's mission is to develop the profession of social entrepreneurship around the world. Ashoka invests in people. It is a global non-profit organization that searches the world for social entrepreneurs - extraordinary individuals with unprecedented ideas for change in their communities. Ashoka identifies and invests in these social entrepreneurs when no one else will. It does so through stipends and professional services that allow "Ashoka Fellows" to focus full time on their ideas for leading social change in education and youth development, health care, environment, human rights, access to technology and economic development. Ashoka has invested in more than 1,200 Ashoka Fellows in 42 countries. Those Fellows have transformed the lives of millions of people in thousands of communities worldwide.

Among the entrepreneurs Ashoka has backed is Rodrigo Baggio. With grant money from Ashoka, Rodrigo has trained almost 60,000 at-risk children with computer and Internet skills. His project, the Committee to Democratize Information Technology (CDI), created a network of more than 200 self-managed computer schools in the urban slums of 17 Brazilian states. Helping students who might otherwise have turned to drug trafficking or violence, Rodrigo is bridging the digital divide while providing important job opportunities to young Brazilians. His project is expanding exponentially as he opens schools in Japan, Colombia, Mexico and Uruguay with partners like AOL, Microsoft, Starmedia and the InterAmerican Bank.

Ashoka Fact Box:

- Elected over 1,200 Ashoka Fellows in 42 countries since 1981
- Ashoka Fellows work in the 6 broad fields of
  - Learning/Education
  - Environment
  - Health
  - Human Rights
  - Civic Participation
  - Economic Development
- We elect approximately 150 new Fellows each year
- Ashoka is not a foundation, nor a government agency. We do not accept government funds (only funds from private individuals and foundations).

Ashoka was founded by Bill Drayton, a former McKinsey & Co. consultant and assistant administrator at the Environmental Protection Agency. An activist since his days as a New York City elementary school student, Drayton is truly a lifelong social entrepreneur. One of the first leaders to recognize the power of individual innovation in addressing pressing social problems, Drayton piloted Ashoka in India with a budget of less than $50,000. Today, Ashoka spends more than $7 million a year financing its Fellows around the world.

2. What is a social entrepreneur?

Ashoka Fellows prove every day that the most powerful force for change in the world is a new idea in the hands of a leading social entrepreneur. The job of a social entrepreneur is to recognize when a part of society is stuck and to provide new ways to get it unstuck. He or she finds what is not working and solves the problem by changing the system, spreading the solution and persuading entire societies to take new leaps. Social entrepreneurs are not content just to give a fish or teach how to fish. They will not rest until they have revolutionized the fishing industry.

Identifying and solving large-scale social problems requires a social entrepreneur because only the entrepreneur has the committed vision and inexhaustible determination to persist until they have transformed an entire system. The scholar comes to rest when he expresses an idea. The professional succeeds when she solves a client's problem. The manager calls it quits when he has enabled his organization to succeed. Social entrepreneurs go beyond the immediate problem to fundamentally change communities, societies and the world.

Ashoka Fellow Veronica Khosa was frustrated with the system of health care in South Africa. A nurse by trade she saw sick people getting sicker, elderly people unable to get to a doctor and hospitals with empty beds that would not admit patients with HIV. So Veronica started Tateni Home Care Nursing Services and instituted the concept of "home care" in her country. Beginning with practically nothing, her team took to the streets providing care to people in a way they had never received it - in the comfort and security of their homes. Just years later, the government had adopted her plan and through the recognition of leading health organizations the idea is spreading beyond South Africa. Social entrepreneurs like Veronica redefine their field and go on to solve systemic social problems on a larger scale.

The past two decades have seen an extraordinary explosion of entrepreneurship and competition in the social sector. The social sector has discovered what the business sector learned from the railroad, the stock market and today's digital revolution: That nothing is as powerful as a big new idea - if it is in the hands of a first class entrepreneur.

In country after country the number of citizen organizations is up hundreds, often thousands-fold. Tiny Slovakia had a handful of such organizations in 1989 and now boasts more than 10,000. Of the approximately 2 million citizen sector organizations working in the United States, 70 percent of them were established in the last 30 years. Eastern Europe has seen more than 100,000 such organizations established in the seven years following the fall of the Berlin Wall.

The revolution - led by leaders like Veronica - is fundamentally changing the way society organizes itself and the way we approach social problems. These leaders are certainly doing more than giving a fish. They are teaching the world to swim.

"While a business entrepreneur may thrive on competition and profit, a social entrepreneur has a different motivation: a commitment to leading through inclusiveness of all actors in society and a dedication to changing the systems and patterns of society."- *Ashoka Fellows in India, April 2000*

3. Ashoka's Innovative Learning Initiative

Since 1981, Ashoka has invested in over 1200 leading social entrepreneurs ("Ashoka Fellows") in 42 countries around the world. These Ashoka Fellows are working in every area of social need, including education, the environment, health care, economic development, housing and law reform.

To draw on the experiences of these powerful innovators, Ashoka launched the Global Initiatives in 1999. The Global Initiatives are identifying and documenting the most successful ideas and strategies Ashoka Fellows are using to bring about broad, systemic social change, and to disseminate these ideas worldwide. The first Global Initiative launched was the *Innovative Learning Initiative* (ILI) due to the fact that almost a quarter of all Ashoka Fellows are working in the areas of education and/or youth development. Ashoka's Innovative Learning Initiative is working to advance and accelerate the spread of the work of this group of powerful innovators.

The Innovative Learning Initiative is:

- Fostering communication and collaboration among the almost 300 Ashoka Fellows through international and local meetings, newsletters, listservs and internet discussions.
- Identifying the principles upon which the work of the almost 300 Ashoka Fellows is based and the practical strategies used to make the principles work.
- Promoting the implementation of the principles and strategies worldwide through key change agents worldwide, including educators, leaders of youth groups, policymakers, the media, business leaders, multilateral organizations and others who can advance change in the field of education.

4. The Innovative Learning Initiative Principles and Strategies

Ashoka's *Innovative Learning Initiative* is examining the work of the almost 300 Ashoka Fellows around the world who are creating innovative change in the lives of young people. As we conduct this research and analysis, we see patterns among the Ashoka Fellows' work and have identified key ideas or "principles" that Ashoka Fellows around the world are using to transform education systems, the learning process and the way children live and grow.

The criteria used to identify these "principles" was the following:

I) The principle must empower those around the world who are working directly with young people. The principle must help those who are working to teach and raise young people to address more easily and efficiently the challenges facing young people in today's changing world. The principle must be one that is simple enough for any teacher, principal, parent or leader of a youth development organization to implement, and, by implementing the principle, it will make it easier for these actors to succeed in changing learning and improving children's lives.

II) The principle must be about how human or institutional relationships are organized. The principle must change relationships between young people, those working with young people, and the institutions involved with helping young people learn and grow. This reorganization will have an impact or create change simply because of the different organizational or relationship structure. The principle must be something that the parent, teacher, principle or youth leader could implement without substantial training or research. The principle will create change based on how the relationships or institutions are organized differently rather than by requiring an understanding of new teaching methodologies or new research on learning. It is the different organizational structure that helps create the change.

III) The principle must be designed to intensify learning. The formal education system covers too little of a young person's life and too little of his or her day to truly shape and guide a young person's growth and learning. The principle must help expand the impact of learning beyond formal schooling by: increasing and diversifying the participants in learning; broadening the content of learning beyond traditional formal school lessons; and, sustaining and intensifying learning throughout the day.

IV) The principle must be universal. The principle must apply to all ages and in all regions of the world.

Using this criteria, below are some of the key principles that the *Innovative Learning Initiative* has identified, and the strategies that illustrate these principles.

4.1. Integrate Learning into Children's Daily Lives.

Effective and sustained learning will ultimately be impossible if it is kept separate and apart from family, work, play and the community. For this reason, Ashoka Fellows are integrating learning into the structure, rhythm and pattern of children's daily lives. Ashoka Fellows are also integrating learning into children's lives by ensuring that the content and substance of what children are taught is relevant to their experiences in their families, their work and play lives and their experiences in the surrounding community.

Take into Account Real-life Barriers to Participation in School. For many children around the world, to go and stay in school, schools must take into account and accommodate real-life obligations or barriers that serve to make participation in school difficult. Many children do not attend school because of rigid timing and inflexible school schedules. Some children need to take care of younger siblings while parents are working or farming. Other children do not attend school because they have to work in factories, scavenge or beg to bring income to the family. For many other children who do attend school, it is impossible to study at home at night, because of work, family pressures or lack of electricity or study spaces. For these reasons, many Ashoka Fellows are making learning more accessible by accommodating these realities of children's daily lives.

Ashoka Fellow Example: In Bangladesh, Ibrahim Sobhan recognized that children from poor families had neither the time nor resources to study at home. He understood that if schools emphasized and relied upon after-school homework, many children would become frustrated and drop out of school because they did not have the time or place to do homework. Taking this reality of Bangladeshi children's lives into account, Sobhan doubled the length of classes from 30 to 60 minutes, created groups in which children could work with and learn from other children, and eliminated homework.

Make the Content of Learning Relevant to Children's Lives. Ashoka Fellows also understand that to sustain and foster an interest in learning – both on the part of children and on the part of their parents -- the content of learning must be relevant to children's lives. For that reason, rather than teaching subjects or teaching in a manner that is separate and alien from children's lives at home and in the community, Ashoka Fellows are taking into account – and for the first time working with -- the different institutions and actors in children's lives and ensuring that school and learning are connected and relevant to the children's lives and to these other actors and institutions, especially when teaching traditionally more abstract subjects like math or science.

Ashoka Fellow Example: In Brazil, Silvia Carvalho is helping very young children learn to read by exposing them to real texts. She recognizes that learning to read and write is a long process that starts well before formal schooling – in fact, from the moment young children have their first contacts with the written word (seeing written messages around them at home, in the streets, through media). To help teach reading, her program promotes reading children newspaper reports, short messages, songs, advertisements, books, or simple recipes (which are later on prepared with the children's participation). Given that reading requires understanding what is written and not simply a mechanical decoding of isolated letters, words or graphic symbols, children are encouraged to have direct contact with different kinds of real-life texts.

4.2. Create a Dynamic Point of Contact with Children

Many children become disconnected and disinterested in school – and ultimately drop out -- because they do not find school sufficiently engaging or because they are failing academically. To get children engaged and interested in learning, many Ashoka Fellows, as a first step, find a dynamic, interesting and meaningful "point of contact" with children. They identify and engage young people in activities in order to build a connection with them and get the children interested in learning again.

Ashoka Fellows have also found that they are able to use the "point of contact" itself – whether it is sports, or dance or computers – to teach young people important skills, information and values (e.g. leadership, critical thinking, decision making, problem solving, team work). The "point of contact" gives the young person an opportunity to shine outside of an academic setting, building the confidence and self-esteem that is so critical to improving school performance. This is especially important when dealing with marginalized children (e.g. favela children, street kids) – but it is effective with all young people.

Ashoka Fellow Example: In Bangladesh, Mostafa Shiblee is engaging and organizing young people in *"debate clubs"* in order to divert their attention away from antisocial behavior and toward informed political discussion and civic participation. The young people identify and analyze a problem, develop creative, well-reasoned arguments; they learn about current issues and discuss them in legitimate constructive form; and, they learn new approaches to group dialogue and conflict resolution and important organizational and public speaking skills.

4.3. Put Children in Charge

Around the world, Ashoka Fellows are putting children in a position of responsibility or authority in order to intensify their learning process and teach them important life skills. By putting children in charge of activities or programs – such as tutoring other students or managing a community program – children learn important and invaluable communication, leadership, decision-making and other life-skills.

Ashoka Fellow Example: In Nigeria, Precious Emelue is building bridges between unemployed and alienated youth and the region's major international investors. Precious' idea is to give the local people a stake in oil exploitation and give the transnationals a way to benefit the local economy. To do this, he has rural youth participate in an alternative to traditional vocational training that puts greater emphasis on an immediate application of skills in the marketplace. From the job-related training the young people launch and lead new businesses that are financed with a credit/finance mechanism.

4.4. Partner Young People from Different Worlds

To build stronger communities and teach young people important lessons about respect, cooperation and teamwork, many Ashoka Fellows are connecting and creating partnerships between young people who are poor and those who are wealthy, and between those from urban and those from rural areas. Ashoka Fellows bring these young people together to engage in real activities or common projects – not simply meetings or discussions. The young people learn to respect and appreciate differences, they learn teamwork, they learn a sense of civic responsibility, and they learn lessons about the impact of concerted civic action. This experience helps create stronger communities by building respect and understanding among diverse groups.

Ashoka Fellow Example: In India, at least half of the students enrolled at Sister Cyril Mooney's middle-class school come from slums in the surrounding area. Sister Cyril believes that having middle-class children and poor-children attend school together and working together on common projects will promote greater understanding among segments of the community and will build a greater sense of responsibility for others, which is so necessary for a well-functioning community. Sister Cyril also runs a "Rural Outreach" Program, in which one time per week children from her school go to rural villages to teach math and science. These children also work with kids in the villages to develop and implement common projects of their own choosing. This helps the rural and urban kids develop a true connection and understanding of each other. It gives the kids a sense of responsibility for those in other parts of their community or region and it gives them a chance to experience success at working with others from different sectors of the community.

4.5. Partner Parents with Young People to Change Parents' Behavior

Many Ashoka Fellows are changing parents' behavior and improving parenting by engaging parents in activities and experiences with their children. Improving parenting and family life is a critical step in changing the lives of children. Too often parents have had their own bad experiences in school – or simply do not see the value of education – and thus are not supportive of their children's participation in school. Many parents, who are working long hours and have too little time to spend with their families, are unable to engage their children in conversations or meaningful activities. Ashoka Fellows are helping to bridge that gap. They are creating activities and experiences in which children and parents can learn together. This intensifies the learning process for the young people, helps reconnect parents with their children and helps improve parenting skills.

Ashoka Fellow Example: In Hungary, Bernadett Takacs has created a play center where parents can bring their children (ages 3-8) to play with a range of toys. Parents can not drop children off, but rather must stay and play with their children. At the play center, there are a number of educational specialists and child psychologists who are on hand to recommend toys or help parents interpret a child's behavior through play. These specialists will only participate if asked by the parent. Bernadette believes strongly in recognizing the competence and abilities of parents. Her goal is not to teach parents certain techniques, but rather to initiate positive social interaction and play, to observe the things that interest children, and to encourage independence and courage in parents, involve them in planning and provide them with positive reinforcement in dealing with their children.

4.6. Democratize Teaching

Many Ashoka Fellows are working to make "teaching" the responsibility of everyone in the community. They are trying to make teaching something that many – parents, community leaders, others -- not just the "professionals," can do. Ashoka Fellows recognize that to ensure universal, constant and continuous education, formally trained, professional teachers cannot be the only ones who participate in the teaching of children.

For this reason, Ashoka Fellows are reconnecting children and their learning with other actors in the community, shifting greater responsibility for the children both in and outside of the classroom. They have targeted society's perceived indifference to children – especially poor children – and identified important new roles for members of the community. Parents, community groups and business leaders are engaged in identifying what skills, values and information children need to be taught in school, developing curriculum, discussing student and community needs, supplementing limited resources, directing programs for young people and finding solutions to school problems, such as drop-out rates and absenteeism.

Ashoka Fellow Example: In Colombia, Raúl Collazos has developed a system for rural education that provides opportunities for parents, teachers, children and members of the community to assume responsibility for education by bringing them together to collectively identify, design, and implement development projects. Educational activities are then constructed around the project. Education is put in the context of a process of community problem solving, and thus more relevant to students' lives.

4.7. Enrich Teaching by Enriching Teachers' Experiences

Ashoka Fellows are helping teachers become effective, interested, engaged leaders for children by enriching teachers' lives through active, engaging experiences -- such as, field trips, exposure to art and literature, or learning about democracy through role-playing a parliamentary system. Ashoka Fellows recognize that teacher training cannot be based on the way the teachers themselves were taught as children. Instead, teacher training must be based on new techniques that stimulate thinking and understanding. Teachers must be engaged in learning – and they need to instill a love for life-long learning in children.

Ashoka Fellows also recognize that many teachers around the world are frustrated, discouraged, unappreciated and poorly paid. Many Ashoka Fellows believe that to counter this negative environment, it is critical for teachers to be given the tools and authority to succeed at their jobs. They believe that teachers will be motivated and effective – despite the poor pay -- if they have input into curriculum and school policies, if they are viewed as educators not disciplinarians, and if they have the tools to succeed.

Ashoka Fellow Example: In Poland, Alicja Derkowska believes that to teach children about democracy, teachers must first have real life experiences with democracy. Ala is giving teachers a chance to role-play democratic processes, engage in simulations of local government procedures and other active experiences. Ala also is teaching teachers innovative techniques that help to foster democratic skills such as listening carefully, respecting others, being able to function in a group, being involved and ready to take responsibility and being aware of others needs. In addition, Ala is enhancing their teaching by exposing them to an international network of schools (Russia, Central Europe, the Baltics) where teachers can participate in educative exchange programs. Through these exchanges, teachers are exposed to other cultures and languages, and build intercultural friendships and ties.

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Education Program for Environment, Safety, Quality and Social Responsibility: The Case of Transpetro S A Company and Surrounding Communities

Edison Durval Ramos CARVALHO, Samuel MACARINI and Lucilene ANCIGUER

Rua Cônego Nery, 140 apto. 13 – Guanabara
CEP 13076 080 – Campinas – SP – Brasil

Abstract: Since 1990, the Group of Interdisciplinary Application to Learning – GAIA – has been developing the Environmental Education Program – PEA – through 12 Brazilian states. Their target public are teachers, students, industrial and rural workers, fishermen, community leaders etc. The total number of people involved is around 48,000. This paper presents the results and proceedings for implementing a PEA in pipeline intersected cities. Some alternatives that can contribute to creating sustainable societies are discussed. Among them, some show up: institutional partnerships building, teachers and local leaders capacitating to themes like safety and environmental education, and elaboration of projects for lost fund or micro-credit funding agents.

1. Introduction

If the environmental problem's relevance became a fact in the 60's, the use of sustainable development concept's principles became a goal in the 90's. This paradigm is based on the integration of modern questions like environmental protection, social justice, economic viability, local culture appreciation and space occupation equalization. These aspects can contribute for the world citizenship.

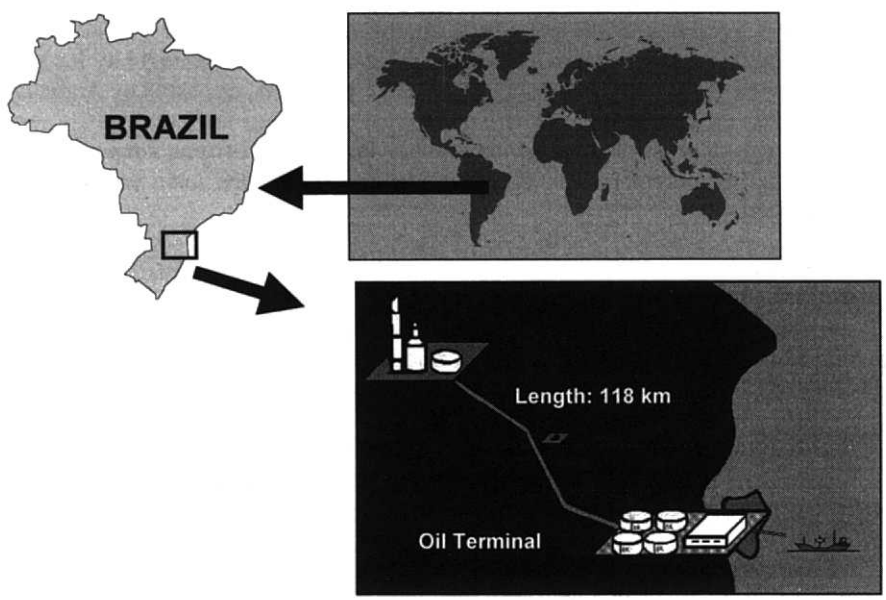
After comprehending this contemporary society specificity, the non-governmental organization Group of Interdisciplinary Application to Learning (in Portuguese, GAIA), since 1990 has been elaborating the Environment's Education Program (PEA), which includes educational and environmental questions like income generation, safety and occupational health aspects, to promote life quality at companies – managers, employees, customers, suppliers - and its surrounding communities – teachers, students and other community members.

GAIA's directed action and its projects have theoretical and strategic origins on the contemporary principles of Sustainable Societies Development and Ecodevelopment, discussed by Herreira (1,2), Sachs (3-5), May (6,7), Cavalcanti (8), Maimon (9,10), Norgaard (11), Unep (12) among others. Among the subjects discussed by these authors, we have: partnership of public and private sectors and NGOs; the social responsibility of public power, private companies and non-governmental organizations; obtaining green seals and implanting integrated management systems for the environment, safety and health; enabling for autonomy and local/world citizenship practice; education for the sustainable society: to minimizing impacts on natural resources, and income generation; and, finally, medium and long term views and planning.

GAIA's institutional action has been occurring through partnership articulation, involving private and public sectors and other organizations. This initiative results on concrete actions that enhance the social responsibility levels of engaged institutions.

This work presents partial results of partnerships developed from march to December 2001, between GAIA, Transpetro (a Brazilian oil transport company) and municipal governments of nine Brazilian cities – São Francisco do Sul, Itapoá, Garuva, Guaratuba, Tijucas do Sul, Mandirituba, Fazenda Rio Grande, São José dos Pinhais and Araucária – at Paraná (PR) and Santa Catarina (SC) states, intersected by Transpetro's pipeline (Figure 1-). It will be indicated the adopted proceedings for implementing pedagogical extra-curricular activities towards enabling teachers, students and community leaders.

Figure 1. Map of region (9 cities) of PEA's activities



2. Objectives

PEA's general goal has been to increase the life quality levels. The specific goals have aimed to improve the elementary and middle teaching at schools and to increase the environmental preservation, occupational safety, and income generation in the cities intersected by pipelines.

3. Action plan

To reach the above goals, the program had the following stages: coordination activities, inter-institutional meetings, seminars, multiplier agents training, multiplier agents accompaniment.

3.1. Coordination Activities

The coordination activities involved planning of activities – to get data about the cities and the schools, prepare the PEA's scheduling and the pedagogical materials for the next PEA's steps.

3.2. Institutional Integration Meetings

In this stage, PEA's members tried to get the citizen's trust and showed the PEA's seriousness and commitment. These features were very important to the citizen's engagement process.

In each city, PEA's general propose presentation was made for the municipal representatives – mayors, education and environment secretaries – who had the chance to show their suggestions to the program's improvement and adequacy to local demands. There also were interviews with 30 teachers, 20 students and 10 community leaders; these interviews were made based on qualitative research principles, discussed by Andre (13).

The analysis and reflection on the obtained information became a report that allowed to have a better comprehension of educational reality, and the main environmental and social problems of each city.

3.3. Seminars

In each city, it was made a four-hours seminar with an average of 150 persons, totaling 1,300 expectators, representatives from all local community sectors: schools, local government members, NGOs, private companies and so on.

This event had a lecture about PEA that was made by this author and some speeches by Transpetro's representatives, mayor, education and environment secretaries and non-governmental organizations members.

Following, during one and a half hour, the expectators presented suggestions and made questions to the institutional representatives. This stage resulted in greater integration of community and institutional representatives (Figure 2.).

Figure 2. Seminars

3.4. Multiplier Agents training

In each of the nine cities there were capacitated around 20 participants, totaling 180 multipliers that went through a 24-hours course (Figure 3.). These multipliers had the following institutional origins:

- 65% are elementary and middle schools teachers or coordinators, representing a number of 80 schools;
- 10% are high school and college students;
- 15% are rural workers and fishermen, community leaders or non-governmental organizations representatives
- 10% are public servants from local to national levels.

The course program had points like:

- environmental education, sustainable society and ecological development;
- origin, use and transportation of oil and derivatives, showing pipeline passage site in each city. Every course had a 90-minutes lecture about pipeline operation and safety conditions. This lecture was made by a expertise employee;
- self esteem, citizenship and autonomy strengthening;
- interdisciplinary focus on elementary and middle school;
- interface between education, science, technology, society and environment.

The course's didactic privileged interactive and life experience aspects which, according to participants evaluation, made the learning-teaching process very pleasant.

Using GAIA elaborated didactic materials – textbooks and videos – and making environment study activities, the multipliers reached the goal of multiplying the experience to a hundred community people – teachers, students, parents, rural workers, fishermen, public technical officials. This was made through four-hours courses.

Figure 3.Group of multiplier agents

3.5. Accompanying the Multiplier Agents

In preparing for accompanying the agents, GAIA proceeded as follows:
- to seek potential donors for social and environmental projects.
- contribute to elaborating of 30 projects, developed by multipliers, to be sent to lost fund or micro-credit funding institutions: foundations, national and international agencies, non-governmental organizations, companies, public organisms, etc.

In each city it was made 3 eight-hours attendance. During the first one, it was tried to check the reception to and action with the didactic materials – textbooks and videos – supporting the multipliers. The textbook was carefully discussed so multipliers would feel confortable to apply it to their respective audiences. In the second and third ones, there were two goals: The first goal was to heal doubts and verify the number of courses, speeches, and theoretic and field classes realized by the multiplier agents and how was the public's reaction. It was noticed in the last attendance that around 18,000 participants were involved and they evaluated the agents actions as very good ones.

In these educational activities, it was verified that 70% of participants had a very superficial comprehension about pipelines and 30% hadn't any idea. The multipliers action has promoted the information about the safety and operations conditions of transporting petrol and derivatives.

Specially through fieldwork activities, the multipliers have prompted the students interest, excitement and a desire to know. They saw that in a real world context, students can learn about many themes. The discussion and inquiry soon ranged from pipelines operation, soil erosion, water exhausting and pollution, rocks, vegetation, industries, rural and urban management, laws, government policies and so on (Figure 4.).

Figure 4. Group of students making field works

For a continuous pedagogic improvement of PEA, the GAIA instructor must accompany the field activities under the coordination of multiplier agents, recording the fundamental and middle school students' observations for a later classroom reflection and theoretical deepening.

The second goal was to enable multipliers for elaborating projects for lost funds or micro-credit funding agents. This initiative has promoted autonomy. The multipliers have felt motivated to search alternative solutions to their needs beyond local powers. This activity started with the following question: What do I really need in my school or community? Having answered this question, the quantity and dimension of needs was analyzed. According to what was considered viable, it was chosen only one demand, and an elaboration process started being oriented, conciliating the demand with the supporting agent's goal. There is no use elaborating a request for financing teachers capacitating to an agency that has as mission to finance construction of buildings, or vice-versa!

As a subproduct of this initiative, the self-esteem was strengthened, the acknowledgement of the multiplier agents own potentiality and the expression abilities – written – through successive readings and suggestions by the GAIA instructor, who discussed the projects and tried to collaborate to produce well written propositions in conformity with potential supporters' goals. There are in final phase of elaboration around 30 projects related to 15 themes: environmental education and art-education, school and sports materials acquisition, expression and communication, education applied informatics, quality of interpersonal relations in school, building of physical school spaces, acquisition of machinery, equipment and supplies for agriculture and fishing; selective garbage collect and recycling; basic sanitation through education and rodents combating; organic agriculture; promoting coast water cleaning; stimulus to banana-tree straw and thread craftsmanship; historic patrimony preservation and undesired pregnancy of students. With GAIA orientation, several propositions are already being sent to lost funds or micro-credit funding agents. Others are in final phase of preparation. A company is already funding a school construction project (Figure 5.).

Figure 5. Multipliers making projects for funding agents

4. Considerations about the adopted proceedings

This partnership action allowed citizens, local institutions and companies to come nearer, beginning a dialog with potential for generating positive results in education, environmental preservation, safety, and income generation. Citizens felt, for the first time, acknowledged and valued as persons who live in an area where there is effective interaction with an oil transport company.

It must, now, be assured the initiated action's sustenance, strengthening the partnership action, at regional, national and international instances, for attracting partnership supporters, of local/regional projects, so that dreams become each time more viable.

PEA must keep advancing in the (re)elaboration process to be more and more a project for Sustainable Societies Education and/or Economic Development.

5. Conclusions

This experience and reflection showed that partnerships may constitute a very promising path to reconstructing the alternatives to Brazilian and world societies' problems. However, it's important to consider, in any partnership, the existence of compromises, benefits and risks, and that each partner's identity, mission and view must be preserved. Good partnerships are those considered as articulate instruments, promoters of improvement in relevant everyday questions. These ingredients are the seeds of the sustainable society concept that should be urgently incorporated through institution's practices – public, private or third sector. This concept is very wide and works as an excellent paradigm, and its connection to the comprehension of everyday reality and of partnership action can bring improvements in areas like education, environmental preservation and income generation among others. This facts can contribute to enhancing the life quality.

The competence for managing an orchestrated action among partners was a fundamental pre-requisite of this program, aiming to building local sustainable societies. The focus was defining what are local and regional demands, so partnerships could give them real answers.

In the partnership management process, the goal was also to enable local leadership to recognize themselves as agents of their own destiny and citizenship.

Another aspect of partnership construction is that, in a world still dominated by mathematic conceptions of the type cost-benefit, win-win, polluter-payer etc; partners seduction strategies must point, at least on the first moment, to the same Cartesian language. The range of arguments can transit through issues like:

- to be acknowledged as an example of innovative and continuous action on Sustainable Social Responsibility, a theme present at the organizations' everyday reality, and that could work as a competitive difference;
- effective divulgation of social programs to a direct or indirectly involved public, that may signify potential customers and consumers;
- creating a good relationship between public and private sectors, associations and NGOs, from local to national levels;
- creating a new culture of relationship with inspecting organisms – environment, for instance – evolving from perspective measures to an aim-based continuous improvement commitment;
- strengthening the partners which could promote new initiatives in social areas;
- identify the new partner's brand with institutions already with a high national and international respectability;
- display the partners brand in distinct promotional e didactic vehicles such as: videos, tee shirts, banners, fliers, textbooks, etc;
- learning a partnership action methodology with an extreme potential to mobilization and capacitating, easily adaptable to other sociocultural realities.

Therefore, competence to attract and articulate partners and focus in equating local/regional problems are fertile strategies in consolidating the sustainable principles that can be initiated with point initiatives, that gradually change into wider actions, generating results that have a greater multiplying potential.

6. Acknowledgements

To all GAIA – partners and consultants – and to all who participated on the PEA at Transpetro S A, and to the representatives of each involved cities.

References

[1] A. O. Herreira, *et alli.*, Catastrophe or New Society? A Latin American World Model. Ottawa, IDRC, 1976. p.7 – 37.

[2] A. O. Herreira, As novas tecnologias e o processo de transformação mundial. ACESSO: Revista de Educação e Informática (ed. especial). São Paulo, FDE, dez. 1993. p. 15-21.

[3] I. Sachs, Ecodesenvolvimento. Crescer sem destruir. São Paulo: Vértice, 1986, 207 p.

[4] I. Sachs, Estratégias de transição para o século XXI: desenvolvimento e meio ambiente. São Paulo, Studio Nobel/FUNDAP, 1993, p. 24-7.

[5] I. Sachs, Paradigma do crescimento responsável. Gestão ambiental: compromisso da empresa (Suplemento Especial do Jornal Gazeta Mercantil), fascículo nº 1, 20 de março de 1996, p. 2.

[6] P. H. May, Economia ecológica e o desenvolvimento eqüitativo no Brasil. In Cavalcanti, C. (org.). Desenvolvimento e natureza: estudos para uma sociedade sustentável. São Paulo, Cortez, 1995, p. 248.

[7] P. H. May, Economia ecológica: aplicações no Brasil. Rio de Janeiro, Campus, 1995.

[8] C. Cavalcanti, Sustentabilidade da economia: paradigmas alternativos de realização econômica. Desenvolvimento e natureza: estudos para uma sociedade sustentável. São Paulo, Cortez Editora, 1995.

[9] D. Maimon, Passaporte verde: gestão ambiental e competitividade. Rio de Janeiro, Qualitymark, 1996, p. 21.

[10] D. Maimon, Responsabilidade ambiental das empresas brasileiras: realidade ou discurso? Cavalcanti, C. (org.). Desenvolvimento e natureza: estudos para uma sociedade sustentável. São Paulo, Cortez, 1995, cap. 20 p. 399–415.

[11] R. Norgaard, The illusions of progress In .Development betrayed. The end of progress and a coevolucionary revisioning of the future. New York: Routledge, 1994, cap. 05 p. 49–60.

[12] P. Unep, The greenhouse effect: facts and figures. Industry and Environment, March 1994, p. 4-8.

[13] M. E. D. A. André, A pesquisa no cotidiano escolar. Metodologia_da_pesquisa_educacional. 3ª ed., São Paulo, Cortez Editora, 1994. p. 37–45.

Talent Development in Residential Summer Programmes

Harald WAGNER
Bildung und Begabung e. V.,
Godesberger Allee 90, 53175 Bonn, Germany

Abstract. Possibilities to serve the needs of their highly able and motivated pupils are limited for most schools. Therefore outside-of-school provision is essential for their optimal educational support. The most effective kind of provision seem to be residential academic summer programmes which have been organized in different forms for more than two decades in the United States. A similar German pre-college programme is described which since its inception in 1988 has developed into a most successful educational opportunity for 16 to 19 year-olds: the Deutsche SchülerAkademie (German Pupils' Academy) with a strong emphasis on mathematics and science courses. Details are given about educational goals, structure of the academies, selection of participants and instructors, contents of coursework, programme evaluation, and finances. Future plans include academies with a general theme, bi-national academies, and academies for younger pupils.

1. Importance of outside-of-school provision

The most significant role in the education and development of young people between the ages of 6 and 18 years is played, without doubt, by general education in elementary and secondary schools. They are expected to make provision in order that each child may achieve the highest possible level of development according to his individual ability and willingness. However, this commitment is met in the main only for the large proportion of average and below average pupils and for children with the most varied handicaps and impediments. Of course no school can be suitable for *every* pupil to the same extent and no pupil can expect his school to provide adequately for every type of talent, gift or specialized interest. But all too often children who are very talented generally, who are highly perceptive and have a well developed capacity for concentration and achievement, who are inquisitive and have broad interests at school face idleness, too few challenges, boredom and lack of motivation. The consequences, lamented again and again, are a reduction in the willingness to make an effort, a decline in achievement, behavioural problems or apathy. The less the school is willing and able to meet the special requirements of their highly able students, the more important outside-of-school provision becomes.

2. Residential programmes

Among the many options for such provision (e.g. afternoon courses, clubs, Saturday programmes, competitions or contests, mentoring programmes) residential summer programmes seem to be the most powerful and effective ones. This setting allows total involvement in a certain subject with intensive tutoring and a multitude of social contacts. Particularly in the United States, such programmes have long been a fixed element of outside-of-school provision for highly able students (1).

2.1. The CTY approach

One of the most sound and consistent approaches was developed by the Center for Talented Youth (CTY) at the Johns Hopkins University in Baltimore. It has been emulated by several institutions in the USA (Duke University in Durham, North Carolina; Northwestern University in Evanston, Illinois; University of Denver in Denver, Colorado; University of Washington in Seattle, Washington) and in Europe (Dublin City University in Dublin, Ireland; University of Navarra in Pamplona, Spain).

On February 19, 2002 the Johns Hopkins University published a press release stating that CTY will assist the British government in creating a new Academy for Gifted and Talented Youth, drawing on the CTY model and providing advanced courses for the top 5 percent of English elementary and secondary pupils. The Academy, scheduled to open in the summer of 2002 at the University of Warwick, will admit 100 English pupils for a three week programme of intensive academic work. The programme is eventually expected to enroll 3,600 of England's top pupils and to cost around 20 million GBP (32,4 million €) over five years.

The CTY approach to talent development relies on the use of talent searches via achievement tests to find pupils who belong academically to the top one-half of one percent of their age mates; they qualify to take part in special academic programmes. Since 1979 CTY has identified more than 800,000 highly able seventh grade pupils by means of regional, national and international talent searches. They provide detailed educational and career guidance to pupils who have qualified. A network puts parents in touch with other parents of academically able pupils.

The core activities for the able are, however, the three weeks residential summer programmes which have been held since 1980. In the summer of 2002 more than 4,900 pupils from all over the United States and from more than 20 foreign countries will participate in 14 sessions held at seven sites.

The pupils work in one course on their chosen subject for five hours per day, five days per week. Each evening pupils are expected to spend at least two hours preparing for classes the next day. The courses with an average size of 15 participants are tutored by an instructor and a teaching assistant. Each site offers a variety of courses for the 250-540 residents. Courses cover humanities, writing, mathematics, science and computer science. Parallel courses are provided for the most popular subjects precalculus mathematics and writing.

Time is allotted for socializing, sports and music to provide relief from the high-level academic programme. This, in addition to the actual work, contributes considerably towards the great success of the CTY programme. Many returns to their home communities fortified to achieve better than before, both academically and socially. Students between the ages of 12 and 16 repeatedly attend the programmes, some even taking two successive three week courses. Some very bright pupils even as young as 13 or 14 can become teaching assistants. This helps them develop even more academic and social maturity. Many of the home schools will acknowledge results and achievements from the summer programmes by giving credit and/or advanced standing to the pupils.

In 1992 the talent search and the residential programmes were extended to fifth and sixth graders, while commuter programmes are already being offered to pupils in grade two with courses such as French, Mathematical Problem Solving or Introduction to Environmental Science.

CTY describes the benefits of its residential programmes as follows: "Our courses permit students to work at a challenging pace, explore topics in depth, and study subjects and develop skills that often are unavailable to students their age. Students report that the summer programs experience gives them a better picture of their own academic abilities and potential, helps them to develop better work and study habits, and refines their educational goals. In this regard, all courses enhance the students' overall educational experiences and sharpen their academic skills. The residential component heightens the experience by providing the opportunity to live, work, and socialize with other bright, motivated young people. Students develop lasting friendships as they participate together in a true living and learning community." (2, p.3)

Experiences with highly able pupils have taught CTY "that the most productive classrooms are characterized by:

- high expectations for student performance
- low student/instructor ratios
- faculty who are well-versed in their fields
- motivated students
- active student participation
- flexible instruction." (2, p. 2)

2.2. Pre-college programmes

For pupils 16 years or older and who attend grade 11 or 12 in high school, many American universities organize pre-college programmes during the summer months on their campuses. As an example, the Zanvyl Krieger School of Arts and Sciences and the Whiting School of Engineering at the Johns Hopkins University in Baltimore offer a wide range of undergraduate credit courses and open many of them to outstanding high school pupils (3). Two regular college courses may be chosen which are compacted into five weeks of intensive work. Additional academic activities, guided tours to research facilities, cultural excursions, sports, concerts, a talent show and field trips offer many opportunities to socialize with the other participants and to get an impression of college life and work.

2.3. Science training programmes

An interesting option for upper secondary pupils with high abilities and motivation in science are training programmes at research institutions or at universities. They are designed to provide the pupils with educational opportunities in science, engineering and mathematics beyond school level. Within these programmes, pupils are brought into contact with the instructional staff, research personnel and general resources of colleges, universities, and research institutions.

Programmes involve pupils as junior associates of a research team or as principal investigators on a problem of appropriate difficulty, under the direct supervision of an experienced research scientist. Other programmes provide courses specially designed for the pupils or regular early college courses.

One of the most highly reputed science training programmes is offered by the Weizmann Institute of Science in Rehovot, Israel (cf. 4, p. 752). This institute is devoted to research and teaching in the natural sciences, in mathematics and computer science. Each summer some 75 outstanding science students (high school graduates) from Europe, Asia, the Americas and Israel work alongside top researchers and use sophisticated scientific instrumentation. Applicants are selected on the basis of previous experience in laboratory research, successful participation in national or international competitions or science olympiads, high motivation, interest in pursuing a career in scientific research, recommendations from their home school and interviews. The partcipants can choose a subject in accordance with their own interests. At the end of the three-week-long laboratory period the students are required to present their findings to a seminar and to write a thesis on the completed work. Additional parts of the programme are a four-day visit to a field-school in the Negev desert with an introduction to desert ecology, a tour of Jerusalem and other places in Israel, as well as lectures given by senior Weizmann Institute scientists.

3. The German Pupils' Academies

Inspired by CTY's approach to provide for highly able young people, in 1988 Bildung und Begabung e.V., a non-profit German association sponsored by the Federal Government, developed residential programmes in the summer holidays for 16-19 year-old upper secondary school pupils thus filling the critical gap between the last school years and higher education with a pre-college type of summer academy. Within a few years these programmes have grown into an outstanding opportunity for academically highly talented and motivated adolescents which seems to be quite unique in Europe. They are now well-known by the name "Deutsche Schüler-Akademie" (German Pupils' Academy). Following a visit to one of the academies in summer 2001, the Federal President of Germany, Johannes Rau, assumed patronage over the Deutsche SchülerAkademie.

3.1. Objectives

The general purpose of the Deutsche SchülerAkademie is to provide an intellectual and social challenge for the participants, to enhance their abilities, to establish contacts with like-minded peers with similar potential and motivation and to engage them in demanding academic work under supervision of expert instructors.

The most important objectives of the academies are

- to develop and improve methods and abilities of knowledge acquisition, interdisciplinary thinking, research techniques and autonomous learning
- to challenge intellectual potentials to their limits
- to improve techniques of oral and written presentations
- to exercise cooperation and coordination in group work
- to provide role models through encounters with highly creative, able, motivated and inspiring teachers and scientists
- to experience a community of able and motivated peers, to develop lasting friendships and thus to accept the own personality as valuable and "normal"
- to help pupils with career-planning decisions
- to raise consciousness, that exceptional abilities carry the obligation to use them in a prosocial manner and in responsible leadership.

Achievement motivation, willingness to exert oneself, ability to work in teams, creativity, communication skills, interdisciplinary thinking, initiative and readiness to take over responsibility are key elements of the pedagogical concept.

3.2. Structure

A 16-days academy typically comprises 90 boys and girls, each one participating in one of six courses covering a broad range of diverse academic disciplines. As an example, one of the academies in the summer of 2002 will offer the following courses:

- "Mathematical structure of fundamental theories in physics"
- "Tumour research – an interdisciplinary challenge (Biochemistry, Medicine, Bioinformatics)"
- "Introduction to jurisprudence"
- "Democracy and deliberation (How to deal with conflicts in a pluralistic society)"
- "Enlightened or mesmerized? The concept of 'culture' in our society"
- "Music in the 'Third Reich' and in exile"

A complete overview of the courses offered in all academies of 2002 is to be found in the internet under http://www.schuelerakademie.de/dsa/2002/index.html.

While there is in each academy usually one course in mathematics, one or two in the sciences, and one or two in the humanities, other courses may come from any academic or scientific or cultural area such as introduction to a foreign language and culture (Italian, Spanish, Polish, Chinese...), creative or journalistic writing, music history, computer science, economics, psychology, rhetoric or visual arts to name just same examples. Interdisciplinary subjects are favoured. The idea is to select a certain topic of a discipline which can be treated in thorough depth and breadth within the 16 days and which introduces participants to the terminology, the methods, the research techniques and the literature of that discipline. The total amount of time spent on course work is about 50 hours. The level of work is mostly comparable with advanced university seminars.

Two instructors (scholars, expert Gymnasium school teachers or free-lancers) plan and run each of the courses with a minimum daily duration of 4-5 hours. The rest of the day is filled with additional optional activities such as sports, music (instrumental, choir), excursions, discussions, drama etc. where participants from all courses mix and meet.

Special emphasis is put on the training and improvement of the ability to clearly formulate and present research findings in oral and written form. Prior to the academy the participants are expected to work through a compilation of relevant texts and to prepare a presentation. Extracts from the written reports are later published for each academy in a 150-page proceedings ("Dokumentation"; several examples are to be seen under http://www.schuelerakademie/kurse/index.html).

Between 1988 and 2001 62 academies with more than 5,400 participants were held in boarding schools which have proven to be ideal locations for such programmes in Germany. A complete listing of all academies and courses may be found in the internet under http://www.schuelerakademie.de/akademien/index.html. In the summer of 2002 another seven academies with a total of 630 participants will be completed.

Within a few days each of the academies develops an atmosphere which can hardly be described, filled with enthusiasm and motivation of both participants and instructors with intensive personal relations, discussions, and gatherings until late at night. The numerous overwhelmingly positive feed-backs and evaluations from participants, their home schools and parents as well as from scientific programme evaluation confirm the immense impact the academy has on the participants.

3.3. Selection of participants and instructors

The ideal participant has a high intellectual ability, a strong motivation to achieve, diverse interests, and has already demonstrated far above average achievements. He should attend grade 11 or 12 in the 13-year German school system and thus carry back his impressions and experiences from the academy into his home school.

As there are no routine standardized achievement tests carried out in Germany (as e.g. the Scholastic Assessment Test – SAT in the U.S.) two different criteria are applied to find suitable candidates:

a) successful participation in one of the intellectually demanding national or state competitions and olympiads or
b) recommendations from schools; each year all ca. 4,300 high schools in Germany ("Gymnasium" or "Gesamtschule") are individually requested to nominate one or two outstanding pupils who would match the above-mentioned ideal profile. About 25 percent of the schools respond to this request. Over the years, both criteria have proven to be equally valid in finding the desired candidates.

In 2002 about 300 recommendations came from competitions while schools provided ca. 1,300 names. The total of 1,600 pupils receive a letter of invitation and the catalogue with the description of the academies and the courses offered. Regularly ca. 80 percent of the candidates apply for participation. As there are twice as many qualified applications as there are places in the academies, difficult decisions have to be made whom to admit and whom to decline. Additional relevant and comparable information on the qualifications of the applicants is not available. Therefore, some pragmatic strategies guide the decisions, including (a) the course chosen; (b) proper representation of: boys and girls, winners in competitions and school nominees, individual federal states; (c) school grade (higher ones preferred, lower ones may apply again in the following year); (d) usually not more than one participant per school and no repeated participation of the same pupil in order to include as many different schools and pupils as possible.

Each year some 50 pupils from more than 20 foreign countries are admitted. They are selected by partner organizations or their home schools. Fluent command of German is an additional requirement for these candidates. A one week homestay prior to the academy with the family of a participant of the same course is usually arranged to help practice oral communication in German. Pupils from former socialist countries in central and eastern Europe only have to pay for their travel to the German border while travelling in Germany and participation in the academy for them is free of charge, the cost being covered by donations and contributions from foundations.

The staff of an academy consists of a director, an assistant (usually a former participant), a coordinator for musical activities (choir, instrumental ensembles), and 6x2 instructors for the course work. In total, 105 people have to be found each year to make the seven academies happen. The ideal profile for these persons would include expertise in their fields, additional abilities and interests, pedagogical talent, cooperativeness, idealism, and willingness to an intense, exhausting personal involvement for 16 days. These idealists are found among expert Gymnasium teachers, academic faculty and (in some cases) free-lancers. They receive a modest remuneration for their considerable engagement, but most of them value the exceptional educational situation to work with a highly able and motivated group of young people and they return year after year.

3.4. Emphasis on mathematics and science courses

During the 69 academies of the years 1988 to 2002 a total of 408 courses were held. Mathematics and the sciences were subjects of 175 courses, which is 43 percent of all courses and indicates the strong emphasis which is put on these disciplines in planning the programmes (cf. tab. 1).

Table 1: Deutsche SchülerAkademie – Mathematics and science courses 1988 – 2002

Area	Number of courses
Mathematics	56
Physics, Astrophysics, Geology	51
Biology, Environmental Studies, Chemistry	29
Medicine, Genetics, Psychology	24
Informatics, Artificial Intelligence	15
Total	175

In the following paragraphs it shall be attempted to provide an impression of the variety of subjects and the level of work accomplished in these courses.

Mathematics The most numerous courses (15) were held on "Geometry", "Modern geometries", "Non-euclidean geometries" or "Fractal geometry". Other topics which were treated several times: "Dynamic systems", "Axiomatic set theory", "Topology", "Games, Strategies, Optimization", "Group theory", "Number theory", "Stochastic processes", "Logic and axiomatic foundations of mathematics", "Graphs, networks, and algorithms".

Further courses dealt with "Complex numbers", "Combinatorics", "Symmetries", "Ordinary differential equations", "Mathematical models in election systems", "Vectoranalysis" or "Mathematical methods in neurophysiology".

The last course is a good example for an interdisciplinary approach. The basis of the course work was Jane Cronin's book "Mathematical aspects of Hodgkin – Huxley neural theory". It covers linear algebra, linear and non-linear differential equations and their periodic solutions applied to a model of electrical activity in neurones, developed by A. L. Hodgkin and A. F. Huxley who received the Nobel prize in 1961 for their pioneering work.

Physics, Astrophysics, Geology Courses in astrophysics and astronomy were by far the most frequently offered (20), covering aspects such as time, velocity, and dimensions in the universe, development of stars, gravity, theory of relativity, galaxies and the structure of the universe, black holes, gravity lenses. Several courses treated subjects such as "Elementary particles and the beginning of the universe", "Quantum mechanics", "Fluid dynamics", "Properties of materials" or "Mathematical structure of fundamental physical theories". Other themes related to "Interference optics and holography", "Magnetism", "Ballistics", "Photonics – transmitting data through light" or "Hardware of mobile phones". Two courses treated topics of geology: "Predictability of earthquakes" and "Development of mountains".

The course on earthquakes explained the structure of the earth, continental drifts, tectonics, hot spots, physics of earthquakes, principles of seismographs, evaluation of seismogrammes, possible precautions against the damaging effects of earthquakes, indicators for imminent earthquakes. A seismograph was installed for the time of the academy by which the pupils were able to register the devastating earthquake that happened near Istanbul on 17 August, 1999.

Biology, Environmental Studies, Chemistry Environmental analysis and ecological studies were performed in seven courses; the microcosm of the cell, its physiology and energy budget were treated in three courses. Other topics were "Neurosciences", "Evolutionary biology", "Biological fundaments of social behaviour", "Climate", "Insects", "Biodiversity" or "Self-organization of proteins".

Chemistry courses treated "Photochemistry – reactions with light", "Chirality (dissymmetric properties of molecules)", "Food analysis", "Bioanorganic chemistry", "Development of medical drugs", "Synthesis of natural substances" or "Chemistry of dyes". This latter course presented the history of dyes, natural dyes and their production, food colouring, indicators and gave ample opportunity for hands-on experiments.

Medicine, Genetics, Psychology Two to three courses in this section dealt with "Neurobiology of learning and recalling", "Drugs and addiction", "Medical technology and health policies" and "Mechanisms of perception". Other courses treated "Tumor research", the "Human genome study", "Genetical engineering", "Viruses", "Neurophysiology", "The brain-mind problem", "Ethical problems in medicine" or an "Introduction to psychology".

"Medical technology and health policies" for instance gave an introduction into the history of infectious diseases, HIV and AIDS, therapeutic possibilities, effectiveness of drugs, ethical problems in clinical studies, genes and diseases, allergies.

Informatics, Artificial Intelligence An introduction into state-of-the-art technology was provided by courses like "PC-Networking", "Informatics of logistics", "Possibilities and limits of automatic planning", "Cyborgs and avatars – the society of informational bodies", "Bioinformatics" or "Datagramm networks".

3.5. Effects of participation

Reports of participants are usually nothing less than enthusiastic. Apart from the academic level, the company of similarly interested and zealous young people is particularly praised which remains a lasting impression and results in a network of friendships, reunions and joint academic and leisure activities over the following years. Most of them are amazed by the energies that can be mobilized and the amount of work that can be accomplished by coordinated efforts of inspired instructors and participants.

Ari, an American girl who had previously attended a CTY summer programme in the United States last year, took a course on musical theory in one of the German academies. Afterwards her mother gave us the following report which may serve as a typical example for the overwhelmingly positive feed-back the academies receive:

"I am so grateful to report that her experience was all that we had hoped for, and more. The Deutsche SchülerAkademie program is absolutely exceptional. A tremendous thank you for giving Ari this opportunity. She said she had the best time of her entire life! The Akademie fulfilled all of CTY's goals: The environment consisted of bright, motivated kids who worked and played hard. The faculty was academically committed, protective and engaged in all of the fun-loving activities, from morning drum revelries to dancing side-by-side with the students at spur-of-the-moment parties, to including all kinds of music in the choir's repertoire from Gregorian chant to spirituals.

Ari didn't struggle with the language. Whatever gaps she had filled in quickly with the exposure and what seems to be her ability to absorb language almost like a sponge. The course work was another matter... She learned a lot. By the end of the course she had written and performed with two other students an original composition, sang a solo, analyzed sections of a Mozart string quartet and given a presentation on her analysis.

The host family was a wonderful fit. Ari went to regular school with the daughter who later attended the Akademie with her. She also went to a prom and swam in the Baltic. I expect that her relationship with the entire family will continue for years to come. Since Ari's return home she has received dozens of e-mails and even phone calls from the kids and messages from the faculty and host parents as well. I can tell you that Ari savoured and benefited from every hour that she spent in the program. The experience has already positively influenced some educational decisions Ari has had to make since arriving home. I couldn't have wished for a better experience."

Another girl - Sabina Hasanovic (19) - put her impressions into a poem (translation by the author):

für einige Tage *in einer anderen welt leben* *die geschichte aus einer anderen* *perspektive betrachten*	*to live for a few days* *in another world* *to look at history* *from a different perspective*
kritisch sein und offen *für neue aspekte* *die grenzen der imagination brechen* *mit dem geist fliegen*	*to be critical and open* *for new points of view* *to break the limits of imagination* *let the spirit soar*
für einige tage *lachen und glücklich sein* *langsam größer werden* *raus aus dem körper*	*to laugh for a few days* *and be happy* *slowly growing* *out of your body*
groß werden und bleiben	*to become and remain grown up*

A more objective view on the effects of participation is provided by the results of extensive evaluation studies by Heinz Neber and Kurt A. Heller (University of Munich) (5;6;7). According to self reports two to four years after participation and compared with the best possible control group (pupils who had equally applied for participation but could not be admitted simply due to lack of places) participants experience an improvement of motivation and social attitudes such as interests, self-confidence, cooperativeness and sociability. They report changes in the awareness and the assessment of their own potential – in most cases positive, in a few negative, however towards a more realistic view of their capabilities. Having been in an academy eases the transition from school to university and helps with decisions concerning university studies. The most important effect however seems to come from the guidance to independent studies, the very close personal contact to the instructors and the encounter with like-minded peers. Neber and Heller conclude: "The academy has primarily a general promoting effect on development and competence. It clearly contributes in a positive way to the psychic development of the participants and thus enhances prerequisites for coping with challenging tasks." (7, p.105; translated by the author)

3.6. Finances

The Deutsche SchülerAkademie is substantially subsidized by the Federal Ministry for Education and Research, the Stifterverband für die Deutsche Wissenschaft, and several foundations (cf. table 2). Additional donations come from parents of the participants. This allows pupils to participate for a moderate fee. While the full cost per place (including the overhead) amounts to 1,477 € participants are expected to pay a fee that covers accommodation and food (in 2002: 500 €). Financial assistance is available to needy families so that no one would have to refrain from participating just for financial reasons.

Table 2: Deutsche SchülerAkademie - Budget 2002 in Euros

Source	Expenditure	Receipts
basic cost (whole year organization)	406,700	
summer programmes	524,000	
state funding		478,200
fees from participants		264,600
funding from other sources		187,900
Total	930,700	930,700

participant's fee for 16 days:	500
programme cost per participant:	832
total cost per participant:	1,477
fee reductions/waivers (16%):	50,400

3.7. Recent developments and future plans

For the summer of 2001 a joint German-Israeli academy had been planned to be held at the Israel Arts and Science Academy in Jerusalem. In four courses 32 German and 32 Israeli pupils should have worked on the subjects "Euclidean and non-Euclidean geometries", "The changing earth and the dynamics of life", "The strange world of the electrons. An introduction to quantum mechanics", and "Values in natural sciences", English being the working language. Two of the courses were to be held by German instructors, the other two by Israelis. – Due to the increasing violence in Israel it was decided to postpone this academy until more peaceful times have returned to Israel.

In the summer of 2002 for the first time an academy will be run which has with the concept of *"Time"* a general theme to which the six courses relate from different academic disciplines: (1) "Time and chance – stochastic processes in nature, technology, economy, demography"; (2) "Theory of relativity – the geometry of time"; (3) "Cosmic rhythms – the concept of time in astronomy"; (4) "Age and ageing – biological, sociological, and medical aspects"; (5) "The timeliness of life – philosophical questions"; (6) "Reflexions and realization – how visual arts treat the factor time". A lot of consideration in preparing this academy has been given to the question of how to coordinate the courses and how to facilitate communication of results between them.

An extension of the academic programmes over the next few years is intended in two directions: (a) the number of academies on the pre-college level shall be increased as the number of qualified applicants regularly outnumber the available places by 2:1. Furthermore we strive for an intensified cooperation with our Eastern neighbours; (b) there is a strong demand for residential summer programmes for younger pupils in Germany. Plans are being developed to establish a Junior Academy for 13 to 16 year-olds with an even stronger emphasis on mathematics and science as German universities register a dramatic decline of the numbers of students in the departments of mathematics, physics, chemistry, and engineering. It is essential to encourage highly able pupils – girls even more than boys – at the earliest possible age to pursue their interests and possible careers in these fields. The necessary funding provided, a first Junior Academy could be held in 2003.

References

[1] P. Olszewski-Kubilius, Special Summer and Saturday Programs for Gifted Students. In: N. Colangelo and G. Davis (eds.), Handbook of Gifted Education (2nd ed.). Allyn and Bacon, Boston, MA, 1997, pp. 180-188.

[2] Center for Talented Youth (CTY), CTY Summer Programs 2002 - 7th grade and above. Johns Hopkins University /Center for Talented Youth, Baltimore, MD, 2002.

[3] Johns Hopkins University/Office of Summer Programs, Pre-college and Intensive English Language Programs 2002. Johns Hopkins University/Office of Summer Programs, Baltimore, MD, 2002.

[4] T. Subhi and N. Maoz, Middle East Region: Efforts, Policies, Programs and Issues. In: K.A. Heller, F.J. Mönks, R.J. Sternberg and R.F Subotnik (eds.), International Handbook of Giftedness and Talent (2nd ed.). Elsevier Science Ltd., Oxford, U.K., 2000, pp. 743-756.

[5] H. Wagner, H. Neber and K.A. Heller, The BundesSchülerAkademie – A Residential Summer Program for Gifted Adolescents in Germany. In: M.W. Katzko and F.J. Mönks (eds.), Nurturing Talent. Individual Needs and Social Ability. The Fourth Conference of the European Council for High Ability. Van Gorcum, Assen, The Netherlands, 1995, pp. 281-291.

[6] H. Neber and K.A. Heller, Auswirkungen der Deutschen SchülerAkademie auf Schule und Studium (Effects of the German Pupils' Academy upon School and University Studies). Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie, Bonn 1996. (Research Report Published by the Federal Ministry for Education, Science, Research and Technology, Bonn.)

[7] H. Neber and K.A. Heller, Deutsche SchülerAkademie. Ergebnisse der wissenschaftlichen Begleitforschung (German Pupils Academy. Results of Evaluative Research). Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie, Bonn 1997. (Research Report Published by the Federal Ministry for Education, Science, Research and Technology, Bonn.)

Science Education Programs for Middle School and High School Students Sponsored by the Howard Hughes Medical Institute

Jill CONLEY
Howard Hughes Medical Institute
4000 Jones Bridge Road, Chevy Chase, MD 20815

Abstract. The Howard Hughes Medical Institute (HHMI) funds not only basic biomedical research, but also supports science education at all levels. This paper describes some of the precollege science education outreach being conducted by formal and informal science education institutions across the United States that are funded by HHMI. In all cases, successful programs involve well-constructed partnerships among scientists, teachers, and/or students and their families. These partnerships connect scientists with today's educators and students, empower teachers to more effectively present new science content to their students, and engage students to experience scientific discovery, and become excited about what they learn.

1. Howard Hughes Medical Institute

The Howard Hughes Medical Institute (HHMI) is a medical research organization dedicated to the conduct of basic biomedical research. HHMI employs almost 350 outstanding scientists, called Investigators, at approximately 70 institutions across the United States. These Investigators pursue research in the fields of neuroscience, genetics, cellular and developmental biology, structural biology, immunology, computational biology and bioinformatics.

In addition to supporting basic research, which HHMI does nationally as described above and internationally through a grants program to support scientists outside of the United States, HHMI also is a leader in its support of science education at all levels. The graduate science education program supports predoctoral scientists, postdoctoral scientists, and medical students who would like to conduct laboratory research. The research resources program provides funding to medical schools and academic health centers to build and enhance new core facilities, to attract new faculty, and to support pilot research projects for faculty to obtain preliminary data with which they can pursue other grant support. HHMI's undergraduate science education program is the largest privately funded effort of its kind in the United States. Through this program, grants to colleges and universities provide funding for precollege outreach, faculty professional development, new course development, and improvement of student laboratory facilities. A new competition is currently underway to select HHMI Professors who will be identified not only by the high quality of their research, but also by their demonstrated interest in and contributions to science education.

HHMI also has a unique program called the Holiday Lectures on Science. Each year, one or two outstanding scientists present a 4-hour lecture series over two days to a live audience of two hundred local high school students at HHMI headquarters. The lectures focus on scientific topics of interest to students, and present state-of-the art scientific information. The lectures were broadcast live via satellite and were followed by a live and electronic chat with the lecturers. Now, we are focusing on web casting the lectures in real time, and are linking in remote sites nationally and internationally. The lectures were previously available free on videotapes, and will now be made available to teachers via DVD. These lectures are supported by materials on our Biointeractive website, providing curricular supplements and suggestions for use of the lectures. This website also features virtual labs and animations that illustrate complex scientific concepts.

2. HHMI Precollege Science Education Program

HHMI also has a program dedicated entirely to precollege science education. The programs supported by HHMI are designed to make science and science activities more accessible to the young people who will become future scientists and to provide schools and students with links to the established scientific community. Through these efforts, teachers and students alike are encouraged to participate in hands-on training and to share what they learn with others. The primary objectives of the program are to address national concerns about the level of general scientific knowledge and interest in both school-aged and adult populations, to provide teachers with research opportunities and access to new teaching tools, and to encourage students to pursue scientific careers.

This program is divided into three areas. The first focuses on teacher professional development, and is currently conducted through a grant to the Woodrow Wilson National Fellowship Foundation. This program identifies exceptional teachers throughout the United States and brings them together over the summer to work together to create new curricular materials. At the end of the summer, these teachers return to their home institutions and serve as master teachers to their colleagues. A strong component contributing to the effectiveness of this program is the continued support these teachers receive through networking; the teachers stay in touch with their colleagues electronically, and provide support and encouragement throughout the year.

The second facet of HHMI's precollege science education activities takes advantage of the unique scientific resources available at medical schools, academic health centers, teaching hospitals, and biomedical research institutions. Grants to these institutions support precollege outreach to students and their families, and teachers. The principal aim of this initiative is to develop and to conduct educational activities in modern biology or in other disciplines integrated with biology. This effort draws on the unique resources that biomedical research institutions can offer to stimulate interest in science, particularly among young people. This initiative encourages a greater role for practicing scientists in education—including textbook and curriculum development and teacher training. It enables science-rich institutions to work with schools, youth organizations, and community groups. This initiative tends to focus on older children, generally in middle school and high school, and usually provides unique hands-on laboratory experiences that students would otherwise not receive through their public school system.

The final initiative in HHMI's precollege portfolio is directed to institutions supporting informal science education. Informal science education institutions are those at which people choose to spend their time, rather than being required to as they are, for example, required to attend school. Grants in this initiative are made to science museums, aquaria, botanical gardens, nature centers, and zoos, and provide science opportunities for children of all ages, but primarily focus on elementary and middle school children. The goals of this program are:

- to strengthen the science literacy of teachers, children, and their families;
- to enhance teachers' skills in teaching science;
- to provide resources to support improved science teaching;
- to engage families and communities in their children's science education;
- to increase interest in science education and research careers among children and youth, including those historically underrepresented in the sciences; and
- to foster collaboration among informal science education institutions and community institutions.

These institutions supplement the opportunities children have to learn science through their coursework at school, often providing them with unique leadership and mentoring activities.

The success of the precollege science education activities funded by HHMI is largely due to carefully constructed partnerships. The institutions conducting the outreach, whether they conduct basic biomedical research or whether they focus on informal science education, must know their target audience and be able to effectively engage them. Our grantees reach a diverse group of students, ranging from inner city high school children to isolated rural populations. Often times these students are educationally underserved, and the institutions providing the outreach can throw an education lifeline to children who might otherwise have little to grasp onto.

The partnerships involve research scientists, the students themselves, their teachers, and their families and communities. Especially when working with younger children, involvement of the family or community is vital for the success of the experience. Children need the reinforcement and validation that can only be provided at home. The scientists provide mentorship and the accurate contemporary science content that teachers, who are generally overworked, have little time or training with which to become or stay current. Teachers are key to these partnerships, since they drive the curriculum and are responsible for what the student experiences in science. The students themselves need to feel engaged and challenged, and often learn much more when required to teach peers or younger colleagues.

The following examples illustrate some of our successful grantees, and the techniques they employ to forge their partnerships. Included are a mixture of grantees from both our biomedical research institution initiative and our informal science education initiative. Two very successful activities funded by HHMI, the program at Rockefeller University and the program at Montgomery County, will not be described here since they are already represented at this meeting.

3. Examples of HHMI-Funded Precollege Science Education Activities

3.1. The Chicago Academy of Sciences

The Chicago Academy of Sciences is developing a model program for underserved teenagers that will allow them to explore science, technology, and career connections. This program, Teens Exploring and Explaining Nature and Science (TEENS) is a year-long, multi-component program that serves students in an experience of engaging science and technology inquiry with scientists and educators in a unique museum setting. The TEENS program has been carefully crafted at the request of community members who asked for more opportunities for academic achievement, training in current computer technologies, and parent involvement. The TEENS program has three levels, each building upon the previous one.

- In the first level, 7^{th} and 8^{th} graders meet weekly after school at the museum to do hands-on investigations of science and technology.
- In the second level, freshmen and sophomores work in the Nature Museum two Saturdays a month learning biology, zoology, and ecology, and develop strategies for public program with Academy staff while exploring career connections.
- In the third level, juniors and seniors participate every Saturday as Science Guides, and create and implement public programs in the museum. This gives them the opportunity to explore real-world science applications, develop web-based resources, and research career opportunities.

Parents and caregivers play an active role in this program by supporting their teen's educational ambitions. A "contract for success" is negotiated between the student and his/her parent upon enrollment in the program to formalize parental participation. A parent advisory council has been created to help shape and direct the growth of the program. Parent workshops, delivered three times per year, focus on topics such as college admissions, financial aid, and academic standards.

In order for parents to increase their understanding of the types of science courses required for current college curricula, a portion of each family workshop is devoted to reviewing the science, contemporary applications, and career opportunities in biology, chemistry, and physics. Learning science together in the non-threatening environment of a museum provides parents a foundation for guiding their children through high school science requirements and eventually into college admission.

3.2. The Dakota Science Center

The Science in the Circle of Life camp creates a bridge between isolated Reservation and rural communities and the University of North Dakota science community. Dakota Science Center is building this bridge by using their experience and expertise in informal science education methods combined with their established relationships with the Native

American community in North Dakota. These populations are underrepresented in scientific research and in science careers. To positively affect minority youth's attitudes toward science, to encourage their pursuit of science-related study in high school and college, and to create an interest in science issues and careers, Dakota Science Center is trying to construct positive empowering experiences in science and research settings for these young people in their middle school years.

The Center is establishing a unique student/teacher/faculty research partnership by linking North Dakota American Indian and rural middle school students with researchers conducting studies at the University of North Dakota, incorporating the latest technology into the research. Exploration of relevant biological and environmental science subjects such as water and air quality, wind and solar energy, plant biology, and health issues such as diabetes, alcoholism, and lung cancer can ignite students' interest and confidence in self-directed study.

Native American counselors, middle school teachers from reservation schools, Elders serving as "Camp Grand Parents" and training of staff and faculty mentors ensures that a safe, supportive, and culturally sensitive environment is established that greatly enhances the campus experience. From the first day when Indian and non-Indian college age counselors, accompanied by Elders from each tribe, pick up campers at each Reservation and in each community to the final day when teams present multimedia posters to family and friends the camp supports inquiry and collaboration.

With support from the Dakota Science Center staff and the University of North Dakota native Media Center, team multimedia research projects are presented. Family members, Elders, faculty mentors, program leaders, and counselors are part of a final camp banquet. Students are encouraged to communicate throughout the year, and stay connected to each other, the counselors, teachers, and faculty mentors.

3.3. New Jersey State Aquarium

The New Jersey State Aquarium program, called the Camden Aquarium Urban Science Enrichment program (CAUSE), aims to achieve greater participation of underrepresented minorities in the science workforce by providing early intervention of quality science education to underserved youth. The primary program objective is to strengthen the science literacy of at-risk youth.

Launched in 1993, the CAUSE program has four major program areas:

- Science education and employment for teens
- After school K-8 ecology clubs
- K-8 summer science camp, and
- A parents' initiative to provide opportunities for parents to be involved with their children's science education.

The program is designed to train high school youth in marine science and biology for paid employment in the aquarium as junior staff. As junior staff, the teens work as exhibit interpreters at the aquarium and as educators and mentors for younger children in the after school ecology clubs and summer camps.

The community has local high school dropout rates exceeding 50%. The overwhelming majority of participants are from low-income households.

The program is a collaboration of the aquarium, the Camden Board of Education, five high schools, three elementary schools, and the Coriell Institute for Medical Research. To date:

- 100% of CAUSE seniors have graduated from high school
- 88% of CAUSE junior staff students have enrolled in college; of these, 73% have received scholarship support
- a total of 1,331 disadvantaged youth have benefited.

3.4. *University of California-Los Angeles*

The goal of UCLA's program is to enrich the science experiences of the teachers and students of California through a comprehensive program of technology, hands-on, and research-based experiences. The components of this integrated biomedical outreach partnership include:

- the technology-situated problem solving IMMEX Project
- the state of the art molecular biology hands-on classroom activities of outreach partners in San Francisco
- a combined faculty, teacher, high school student research partnership program.

The first two components are well-established programs having individually impacted hundreds of teachers and thousands of students and, when combined through this program's activities, are providing new insights into the effective interactions among these different instructional modalities. The third component is an experimental extension of these established programs that will create 24 faculty/teacher/student research partnerships, expanding the opportunities for the teachers who have already participated in the month-long IMMEX outreach activities. These partnerships will enrich the experiences of students aspiring for a research career, and expand the science content/process knowledge of the teachers. This effective and unique science partnership will impact teachers and students directly in two major metropolitan areas and indirectly across the country.

3.5. *Cable Natural History Museum*

The Cable Natural History Museum's Forest Lab intern Program (FLIP) provides science education programs for teens in rural northwest Wisconsin. Their target audience also involves high school students, fourth grade students, a preservice intern teacher, community members, and over ten thousand radio listeners.

FLIP provides students from public high schools, a Native American Reservation school, and the home-school community with paid eight-week summer science internships. Under the leadership of an instructor, the FLIP interns visit and work with scientists in the field and lab. The FLIP program gives the students a powerful immersion experience in natural science just before many of them begin making choices about college careers. While these students have studied science in a classroom setting, the FLIP program adds a meaningful context by showing how academic study translates into the field work, lab work, and policy design that constitute the daily work of professional scientists. Through the FLIP program students begin to develop a realistic sense of what a science career entails, and they also learn the rich science of an environment they are very close to but take for granted.

The FLIP interns design inquiry- based science field trips, which they lead for their classmates when they return to school in the fall. In addition, the interns plan and carry out Science in Action Week – a serious of demonstrations, field trips, displays, and brief interpretive programs they provide for Museum visitors. Four Science Saturdays for museum visitors provide workshop-style programs in which the public can work side-by-side with scientists and the FLIP interns. A preservice teacher intern assists with programming, and a visiting scientist in residence will assist the interns to develop their field trips and provides a public lecture about his/her specialty.

The preservice teacher intern will also assist the interns in identifying and testing a scientific problem; the interns will present their results at a junior science and humanities program. The preservice teacher intern will develop fourth grade curriculum that incorporates national sciences standards. Museum staff will implement the curriculum with assistance from the FLIP interns.

Additionally, the interns keep journals of their experience and maintain a museum display about the FLIP program. Another activity allows the interns to interview scientists and produce science radio spots to be broadcast on a public radio station on the Lac Courte Oreilles Reservation.

3.6. Franklin Institute Science Museum

The student leadership in Science program (SLS) was a four-year partnership between the Franklin Institute and the school district of Philadelphia for students in grades 5-12. With the assistance of Franklin Institute staff and adult volunteer mentors, SLS participants developed a model program of student life science research and cross-age mentoring. Each year, senior high school student members of the Franklin Institute's youth science leadership program, "Partnerships for Achieving Career in Science and Technology" (PACTS) conducted research in the life sciences. Their research was primarily concerned with water and water habitats in an urban environment. The data collected by the students was made available to school groups, city organizations, and the general public via the web. PACTS/SLS students also developed traveling research presentation to take to area classrooms. On these occasions, students in grades 5-8 were invited to become members of PACTS. SLS students also led two orientation events per year at the institute to demonstrate their life sciences research to younger members of PACTS.

3.7. The University of Cincinnati College of Medicine

The University of Cincinnati College of Medicine has three parts to its program:

- The high school program (ExSel) is a sophisticated 5-week, total immersion science enrichment summer research program for gifted and talented incoming 12th grade students in the Cincinnati public schools. Three academic year sessions are also planned. College of Medicine faculty in the focus areas will coordinate and teach each of the one-week mini-course and research experiences.
- The middle school program involves 7th and 8th grade public school students and their parents/partners in a year-round Saturday morning hands-on biomedical/biological science enrichment program at the College of Medicine. A different science module is presented each session, developed and conducted by the visiting scientist of the week. Emphasis is on developing critical thinking and

problem solving skills, exposure to a wide variety of sciences, development of decision-making skills and education uses of the computer and Internet.

- The teachers initiative involves middle and high school teachers who are members of or teach large numbers of minority and/or disadvantaged students for an 8-week intensive summer laboratory research experience and periodic meetings during the academic year. Teachers meet with the scientific director weekly to discuss progress and transferability of research skills to the classroom setting and present their work at an end of the program research symposium.

3.8. Cold Spring Harbor Laboratory

Cold Spring Harbor Laboratory has a two-part program to introduce high school students and teachers to the use of modern networked computing in genomic biology. The object is to augment "wet-lab" experimentation on DNA with online computational and database resources. A local program, New York City Genes, works intensively with students from public high schools representing each of the five boroughs of New York City. A national program, the Vector Bioinformatics Workshop, provides training for teachers who have demonstrated interest and leadership in modern genetics instruction.

The VectorNet Laboratory, a stand-alone portable computer laboratory, demonstrates state-of-the-art satellite and local area networking, and supports both program components. The Internet laboratory will be used by NYC Genes students during the academic year and by teacher workshop participants during the summer. Both components draw from a core syllabus and make extensive use of Internet content, data analysis tools, and online communication facilities developed by the DNA Learning Center – as well as educational and research resources available on the web.

Instruction in the curriculum begins with a teacher's or student's own DNA polymorphisms, which then serves as an entrée to computation. Using these personal genetic data as a starting point, six units will cover the major concepts and techniques of genomic biology and bioinformatics: techniques; population genetics; DNA sequence analysis; DNA epidemiology and forensic analysis; mining genes; and ethical, legal, and social issues.

4. Conclusions

These programs provide just a few examples of the precollege outreach being conducted by research institutions, medical schools, and institutions of informal science education across the United States. More information on these programs and on others funded by HHMI can be found on our website: www.hhmi.org/grants/precollege. We have found the directors of our programs are very willing to help others create their own programs, or to share best practices. Contact information is listed with each grant, and my staff can also direct you to appropriate resources.

These institutions use their resources, both in terms of scientific facilities and, more importantly, their scientists, to give teachers support and to help them stay abreast of advances in science and technology. By providing teachers with an opportunity to experience scientific research, the institutions empower these teachers to be more productive in the classroom, and to teach science education more effectively.

Additionally, these institutions have reached out to children and their families who otherwise might not have many opportunities to see science come alive. They have engaged children with the exciting possibilities provided by science, and whether or not they go on to careers in science these children will become more scientifically literate adults.

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Mentor, Merlin, Muse: Inspiring Poets and Scientists

the Illinois Mathematics and Science Academy Program

Peggy CONNOLLY, Eric SZCZESNIAK and Lina NAYAK
Illinois Mathematics and Science Academy
1500 West Sullivan Road; Aurora, IL 60506 USA

Abstract. Young scientists and scholars with a passion for discovery realize their power to create knowledge through active participation in research. The Illinois Mathematics and Science Academy research program nurtures young researchers through a developmental process that integrates structures of critical thought, disciplined uncertainties, and real-world experience. Students collaborate on research projects, develop the skill to conduct independent research, discover innovative techniques, create novel programs, publish in peer-reviewed journals, and present work at professional conferences. The Academy's program design and materials are offered as one model of a successful student research program.

1. Introduction

Ancient cartographers included warnings on their maps for sailors who reached the edge of the known world: "Beyond this point there be dragons". They believed that beyond the point where existing knowledge ended, hapless adventurers would come to a terrible end. The Illinois Mathematics and Science Academy (IMSA) was created with the expectation that our students not only will master what the world already knows, but will venture confidently beyond the known world to create new knowledge and contribute to the expansion of human understanding.

Creation of knowledge and potential for discovery are encouraged when students engage early in their lives in research which stimulates curiosity, engages abilities, and challenges imagination. Becoming a scientist or scholar requires mastering the concepts of the disciplines, conducting worthy and meticulous research, demonstrating integrity and ethical professionalism, and offering the work for public scrutiny and response. It also requires understanding the subtleties of organizations, regulation, funding, ethics, collaboration, and the standards of the profession. The processes and expectations of science and scholarship are not always transparent or intuitive, and success often hard-won and elusive. These complexities, challenging to adults, can be discouraging to young people. It takes a confident learner to tackle problems where the solution is unknown and the way may be treacherous.

When Odysseus left for the Trojan War, he entrusted the care of his beloved son, Telemachus, to his wise and faithful friend, Mentor. Mentor taught the child virtue, skill, responsibility, and discernment. As Telemachus grew older, Athena appeared to him in the form of Mentor. As Mentor, Athena also appeared to Odysseus in difficult times during his odyssey. Mentor gave advice to guide Odysseus safely to his home and Telemachus successfully to manhood. Mentors give young people who venture beyond the known training to attain proficiency and acumen, and nourishment to develop character and confidence.

2. Illinois Mathematics and Science Academy

The Illinois Mathematics and Science Academy (IMSA) is a public residential high school for students gifted in science and mathematics. The student population is multicultural, equally divided between males and females, and reflects the state's geographic demographics. The Mentorship Program was initiated in 1989, and in over a decade of existence has facilitated exceptional opportunities for young researchers to experience real-world research and make significant contributions to science and scholarship. Four years ago, the program was expanded under the new umbrella of Student Inquiry and Research to provide greater flexibility and options for students. IMSA's Student Inquiry and Research Program now includes the student-developed outreach programs of the IMSA Kids Institute, guided inquiry, and mentored research. IMSA's academic program is one of the most rigorous in the United States, and students are not required to participate in Student Inquiry and Research., Even so, at any one time over half the approximately 610 students are active in the program, and most students participate for some or all of their three years at IMSA. Despite IMSA's gifted population, there is a misconception that students successful in research are exceptionally intelligent. Discovery is not the result of brilliant insight, but of diligent commitment. Students achieve great things not because they are gifted, but because they are motivated, and because someone gives them the opportunity.

3. Student Inquiry and Research: The IMSA Kids Institute

The IMSA Kids Institute provides hands-on enrichment programs and projects in science, mathematics, technology and the humanities. These programs are developed by IMSA students for the benefit of Illinois elementary schools, students, and communities. IMSA Kids Institute programs expanded exponentially from the 12 IMSA students who created the 1998 Science Explorers program for 50 elementary students. 150 IMSA students now develop and deliver numerous programs; faculty members facilitate four programs, and co-teach three. Programs rely on an outstanding pool of corporate, scientific, and educational partners; some financial in nature, some resource-based, others a mixture of both .

Current programs include:

- Science Explorers: IMSA students plan and produce two, one-week science day camps, with a capacity of 144 campers
- Science Explorers Field Trips and On the Road: Students provide a half day of hands-on science learning at IMSA. Science Explorers On the Road brings IMSA students to deliver science presentations to schools that cannot bring their students to the IMSA campus.
- Project READ: 50 IMSA students provide hundreds of hours of one-on-one tutoring for 2nd and 3rd graders. Students are also developing a Saturday Enrichment program themed around children's literature.
- Real Science: Our students produce free interactive CD-ROMs, based on annual teacher surveys which identify content areas where additional science enrichment is needed for 3rd to 6th graders. Real Science 2002 is currently under development for distribution to approximately 1,000 Illinois schools and libraries.
- IMSA Team Mars: Students deliver a 16-week, on-line science enrichment unit to selected Illinois schools. The coursework culminates in a Mars Fair at IMSA in May, where students showcase their work.
- Digital Art: Middle school students explore the relationship of art and technology, and integrate learning into electronic design (web art) under the guidance of IMSA faculty and students.
- NEW Math+Science 4 Girls: Co-taught by female IMSA students and faculty, and community members, this program involves middle school girls in discovery-based learning which includes forensics, investments (stock market, futures, bonds), medicine, and aerospace.
- Explorations in Science: A day camp that engages students in molecular biology, satellite imagery, and physics principles.
- Science Explorers @ Walter Payton College Prep: In its second year, WPCP students who were trained last summer by IMSA student-teachers will mentor younger WPCP students in science camp development and delivery .
- Project School Visit: IMSA Science Explorers work with IMSA's Admission Office to provide hands-on science program for minority middle school students.
- Saturday Enrichment Workshops: IMSA students teach grade-school students on Saturday afternoons in Inventors' Workshop, Kids Clay Studio, Architecture Workshop, Project READ, and Ecology @ IMSA.

4. Student Inquiry and Research: Inquiry and Mentorship

In self-directed inquiries, student pose questions that spring from their curiosity or passion. Guided by IMSA faculty or staff, students define questions and design a disciplined process of inquiry to answer them. Unlike research where the answer is unknown to anyone, inquiries may focus on a problem or interest where answers are known to others, but new to the student. Similarly, through in-course and in-class inquiries, students also pose questions and identify appropriate methodologies, but focus on topics relevant to the course of study. Although disciplined, inquiry is not formulaic: the multiple, complex, interacting interests and needs of our students require flexibility. Most inquiries take place on campus, often in the Grainger Center for Imagination. The Grainger Center provides secure individual work stations and storage, fume hoods, equipment, computers, and other accoutrements necessary to conduct research. The adjoining Grainger Workshop has tools, old machines and equipment for tinkering and building customized equipment.

Some inquiries take place off-campus, for example in near-by marshes, museums, or other facilities.

Inquiry and Mentorship involve similar structures, materials, and timelines to develop students' understanding of research. Because they are similar, detailed descriptions of the Mentorship Program will also characterize Student Inquiry.

The IMSA Mentorship Program began in 1989 with twenty-eight students, and now involves about 150 students each year, who actively participate in research in laboratories, in the field, in museums, corporations, and universities. Students are paired with scientists and scholars who welcome them into the scientific and scholarly community, bring the students into their own research, guiding the students to be able to conduct increasingly independent and sophisticated research of their own. The essential components of successful mentorship are student and mentor commitment, and a viable research project. Research may be in any discipline. Projects include research in superconductivity, biochemistry, astrophysics, law, material science, nanotechnology, domestic violence, anthropology, economics, biomedical ethics, mathematics, pediatric oncology, computer graphics, genetics, art restoration, paleontology, environmental engineering, archaeology, neuropsychiatry, fluid dynamics, immunology, public policy, and numerous other fields. Ethics, safety, identification of resources, structuring the inquiry process, presentation, and other aspects of research are addressed in addition to methodologies and techniques.

5. Program Requirements and Materials

Mentorship requirements are developmental, designed to nurture ethical researchers who have the experience, skills, expertise, and judgment to extend the limits of existing knowledge. Students summarize resources from the professional literature, address safety, analyze ethical aspects of their research, and submit a series of reports that build on their previous work. These reports include a research proposal, progress report, and final research report with abstract. Students also give oral and poster presentations of their work. Although the students write their own reports, initially they rely on the mentor for much of the information. As they gain insight, skill, and confidence through their experiences and interactions, students become more independent in their work as well as in their thinking and writing. The mentor's signature on students' work indicates the content is accurate and the work acceptable. Requirements include:

- Application: Students submit an application that summarizes their academic and other preparation for research, and asks them to describe themselves, their character, interests, and special skills. The form documents the quantitative aspects of the student, but also encourages the student to express their passion and motivation for research. The student's passion for particular research is matched with the mentor's expertise. The applications includes summaries of articles from the professional literature.
- Summary and Citation of Resources from the Professional Literature: Before contributing knowledge to a field, it is essential to understand what is known, and what questions remain unanswered. Students must become familiar with the professional literature, understand significant works, develop a solid grasp of essential concepts and vocabulary, learn who the respected researchers are, and what their significant contributions have been.
- Safety Review: Students identify chemical, biological, physical, and radiation hazards in their research environment, equipment, methods or materials; and understand procedures and use of equipment in case of exposure to hazards.

- Ethical Analysis of Research: Students address the ethical aspects of their research. Students must understand and comply with federal and institutional guidelines on human and animal research, and are asked to review IRB (Institutional Review Board) or ACUC (Animal Care and Use Committee) protocols. (By United States law, institution that receive federal funding must have IRB review of research involving human subjects, and ACUC of review research with vertebrate animals.) Students are encouraged to examine professional codes of ethics to develop understanding of standards and expectations for judgment and conduct, and examine and their personal standards of ethical conduct.
- Research Proposal and Reports: Students submit a research proposal, progress report, and final report. Each report includes ethical considerations, context of the research, hypothesis, methods and materials. The final report includes, data, findings and discussion. The content is supported by references from peer-reviewed literature.
- Abstract and Presentations: To invite scrutiny and discussion, students offer their research for examination, replication, modification, and application. Mentorship culminates in the annual IMSA Presentation Day in May, where students give both oral and poster presentations on their work. Mentors are invited from the morning presentations, which are followed by the Mentor Appreciation Lunch. Some students also make presentations at professional research conferences; a few publish in peer-reviewed journals. Publication and presentation in professional venues is the exception, and few achieve at this level, but we are extremely proud of those who do.

The materials continually evolve. As soon as they are updated, something fundamental emerges or changes. Students were required to summarize professional literature pertaining to their research soon after starting research. Students sometimes express interest in a particular kind of research because it sounds interesting, without any real understanding of the concepts. Students are now required to summarize these articles as part of the application. The external environment changes continually, which requires changes in materials. Students were asked on the application if they objected to working with fetal tissue. When the use of fetal materials in government-funded research was banned, the question on fetal tissue was eliminated. However, a new question was added on stem cell research. Students participate in hazardous and controversial research, but additional precautions are taken. When students are placed in a situation where they may be exposed to hazardous materials such a live virus or radiation, they are carefully trained and supervised, and the situation is discussed beforehand with the parents. All students complete a safety review with their mentors. The review identifies hazards and appropriate responses should any adverse events occur. The student and mentor both sign the form, which is sent to the parents for their signature. Many students are not eligible for high school research competitions because they work with vertebrate animals. IMSA's philosophy is not to restrict research with animals or hazardous materials, but to train students to work carefully, correctly, and ethically. Students are encouraged to discuss controversial and ethical issues with their mentors and others, read and reflect on those issues, and acknowledge their own position on those topics.

6. Benefits and Outcomes of Mentorship

The Illinois Mathematics and Science Academy Mentorship program provides a tremendous model of leveraging limited educational resources. Over 100 Illinois institutions – corporations, museums, science laboratories, universities and colleges support the mentors who volunteer 20,000 hours a year. Over the 12 years of the program's existence, some of the greatest minds in Illinois have contributed a quarter of a million hours to nurturing the next generation of scientists and scholars. The record of these young researchers' contributions to date is proof of that research allows students to accomplish extraordinary things. IMSA students have won national and international recognition and awards, including Siemens Westinghouse Science Talent Search and Intel competitions. They have received grants and fellowships, such as the Elizabeth Glaser Pediatric AIDS Award, for their research while still in high school. They have co-authored articles in publications such as "Nature", "Biology of Reproduction", "Meteorite and Planetary Science", Monaldi Arch Chest Dis", and "American Ceramic Society". Students have been appointed to think tanks such as the Santa Fe institute. They have presented their work at professional conferences including the American Chemical Society, American Academy of Pediatrics, American Ceramics Society, Meteoritic Society, and the American Association for the Advancement of Science. Students have made significant contributions to the state of Illinois which funds the academy. For example, IMSA students have created programs to develop high level math and skills, scientific literacy, and self esteem for children living in Cabrini Green, one of the country's most disadvantaged and violent communities. One student, Andrew Torres, invented an immunology technique that was named "The Andy technique" after him, and adopted by other laboratories. IMSA students have developed better intervention programs for abused children, identified why some prostheses disintegrate in the human body, discovered a mathematical formulas to predict the shelf life of soap products, and created an interactive database with students from the Potawatomi Nation that became a model for several other Indian tribes to recapture their culture and history Through the experience of research, the power to learn is elevated to the power of discovery, and disciplined inspiration is transformed into substantive contribution. Mentors, who often recognize more in young people than they see in themselves, help their students achieve their potential and their dreams, and have the satisfactions of seeing see how their protégées are changing the world.

7. Students' Perspective on Mentorship

"IMSA's Student Inquiry and Research Program and mentors, together, provide students the unique opportunity to conduct meaningful research. I conduct research in an off-campus laboratory at Northwestern University Medical Center. The goal of my research is to characterize the adhesion properties of certain cells that have been altered genetically, and to identify genes and proteins that are responsible for adhesion. In the case of cancer, for example, cells remain attached while they develop and divide. When tumor metastasis occurs, the cells no longer adhere, thus allowing the cancer to spread. This demonstrates one way in which the disease process of cancer is related to cell adhesion. Inquiries related to cell adhesion may provide new insights into processes involved in the spread of cancer. The caliber of our student research gives us the chance to make a contribution to the scientific community. When participating in research that has true significance, students, like myself, become motivated and experience the true excitement of scientific investigation.

Through my work in a cell and molecular biology lab, I have recognized the interconnectedness of various disciplines. When I centrifuge cells in order to concentrate a cell solution, I employ the principles of physics. When I calibrate the pH of medium, which is necessary for cells to sustain life, I use my knowledge of chemistry. When I write my research proposal and when I create graphs to visually express my results, I employ the disciplines of math, art, and literature. As students enter a real research environment, the relationships between various disciplines become more apparent.

My experiences in mentorship have catalyzed a curiosity to learn more about the world. When I began my mentorship, I attended a lecture where my mentor spoke on "The Human Genome Project: Progress, Problems and Prospects." The panel presented the complexities of setting public policy on morally contested issues. This eye-opening experience sparked my interest to seek knowledge actively and I sought opportunities to attend other lectures. Through the Chicago Council on Foreign Relations, I attended a lecture given by NATO's Secretary General Lord Robertson. He addressed the idea that geography is not destiny; his words geared young leaders towards finding solutions. I attended a lecture titled "The Big Picture," given by Benjamin Carson, who explained how he overcame dire poverty, poor grades, and a vicious temper to become the youngest chief of pediatric neurosurgery at Johns Hopkins. His inspirational story helped me think about how I can contribute to society by creating a world that works for everyone. I attended lectures given by Dr. Henry Kissinger and Madeline Albright. Participating in research encourages young minds to become more attuned to the world in which they live, and such exposure helps students realize the importance of sharing knowledge in the global community.

The structure of IMSA's Student Inquiry and Research Program guides students through research, encourages them to reflect on the ethical implications of their work, and to present their findings for public examination and response. We first work with our mentors to define a specific project and outline a course of action through the research proposal, This allows us to delve right into our projects and to focus immediately on the research process and goals. Time in the laboratory is devoted to the project. While reviewing pertinent publications, we become familiar with the scientific terminology specific to our particular research. We learn that a single phrase (e.g.: "insertional mutagenesis") can eloquently describe a relatively complex process. When we become comfortable using such terminology appropriately in describing our project, we learn the value of effective communication. (We also learn that in presenting research, communicating with the audience may mean that instead of using this elegant term, "insertional mutagenesis", we need to describe in simple terms that the insertion of foreign DNA into the genome of a host cell may cause a disruption in a gene.) We become confident collecting and evaluating data, creating graphs and discussing results, and we learn to bridge the gap between recording numbers in a laboratory setting and recognizing the true meaning of the results. We gain the confidence to modify the project to make it more insightful and effective.

Through mentorship, students have meaningful personal and professional experiences. I developed a new perspective of scientists, their duty to be responsible, to consider the ethical implications of their work, and report their findings honestly. I see the scientists in my lab work as a team; they use material efficiently and communicate effectively.

When Dr. Chisholm, my mentor, replies to my e-mail at 6 AM, I see the dedication that a real scientist has for his work. In my lab, I witness the enthusiasm and focus with which scientists work; and when I conduct research, I try to emulate this behavior.

Conducting research in a laboratory is an eye-opening experience where students develop a more realistic view of the world.

A student's lab experience can simultaneously involve independent study and guided inquiry. I conduct certain experiments independently. Sometimes my mentor and I make visual assessments together. I record observations and gather quantitative data on my own, but value the dialogue with my mentor and others that serves a critical role in the learning process. On a regular basis, I ask my mentor questions about the project and describe what I do and do not understand. Such discussions reinforce fundamental concepts, clarify ideas, and encouraged me to ask questions.

Although the majority of my time is spent on my specific part of the larger project, I participate in other aspects of the project as well. Sometimes I assist with experiments conducted on cells not directly part of my project. Working with cells in different stages of the life cycle, from spores to fruiting bodies, I am exposed to different steps of the ongoing research process. I study the data that are received from other laboratories with which we collaborate. I review current results on different parts of the project with my mentor and we discuss the implications of the new findings on the overall project. This multifaceted viewpoint encourages students to look at the big picture and value collaboration.

My experiences in IMSA's Student Inquiry and Research Program have helped me develop both as a scientist and a person. The great mentors that participate in this program give students the independence to do actual research. I have learned to ask questions and to discover solutions. I have become a more effective and resourceful communicator, and I better understand the interrelationships among the various disciplines."

"What makes research such a potent stimuli of a student's interest? For most of their education, students learn what others already know. This limits imagination. Finding the sequence of steps in an electron cascade is simple in today's world, but when challenged to find a sequence of steps in a signal transduction pathway of a cell, students find that they do not know where to start. They may be inclined to give up. My mentor ignited a flame! I was so enthused to contribute to the professional world of science, I voluntarily read books on immunology, biochemistry, and numerous other topics to learn the intricacies of such work. I have learned my own thought process, and that I must ask pertinent and useful questions, and wonder why, and think with simple logic. Thinking is only acquired with experience, but this experience is not found in books. At the same time, I have had other valuable experiences. I have made friends who are not my peers. Research put me in an arena of people who like what I like. Mentorship is a program with awesome power."

"IMSA's Student Inquiry and research program develops passion within one's thoughts and feeds it with a wide scope of hands-on, interactive experiences. It allows me to poke around the knowledge that is out there and form a focused path. It gives me the opportunity to learn where there is no path, then make a path to show others."

"I have learned that research is not nearly as simple as the scientific method taught since elementary school, yet at the same time employs the exact same fundamentals. The steps of that familiar process are used, yet I must restart this process, refining it each time. Each time I change part of my process, I am able to eliminate one more factor and come one step closer to achieving desired results. Mentorship has also taught me that science requires a lot of patience. I must be exact and clean. If any dirt gets on a sample, or if I over-etch/over-develop by few seconds, I have to start over. Recently I had redo several weeks' research because my chromium had been contaminated with carbon. I must have the patience to set up everything ahead of time, and above all, avoid the temptation to take shortcuts. I have acquired vast amount of technical knowledge, and cross-disciplinary fields, in a manner much more appealing than in the classroom."

"What makes research so engaging is the people I work with know how to explain their thoughts in a clear and concise manner. However, the answers are not handed to me on a plate: they give me a push, get me excited, then I have to pursue the rest of the problem myself. When I presented my research at a conference, it gave me a whole new perspective on science as a profession. I met others doing similar research, and others doing completely different research than mine. I learned how science news is spread, and that the most important step in research is letting others understand what you've discovered. If others don't know what you've done, your research is quite useless."

"I discovered, through painful self-realization, that I needed to commit to a completely different mindset. I was accustomed to a step-by-step protocol to delineate every minute detail. I found myself with the frustrating task of having to delegate my own experimental procedures. I became exasperated with my many failures and unfavorable outcomes. In numerous trials, my experiments were spoiled by contaminated or the mysterious death of yeast cells. In retrospect, I view these as blessings in (mean, ugly) disguise. Through them, I was able to comprehend the real meaning of research. Research is, in fact, tedious and repetitious. Nonetheless, when I finally produced viable results, I identified with gold diggers whose shovels hit a hard spot. I felt exhilarated at finding the one thing I searched for!"

8. Conclusion

Merlin was one of literature's greatest mentors. As part of Arthur's education, Merlin turned him into different animals. When Merlin asked Arthur to describe his kingdom from the viewpoint of a fish or a bird, Arthur found he could not. He realized that the boundaries between countries are inherently mutable and artificial, and that the knowledge to lead wisely comes through understanding others. This NATO conference reaffirms that the boundaries that separate us are artificial, and when we work together to nurture the next generation of scientists and leaders, we will create a future of peace.

P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Using New Technologies in Physics Teaching to Promote Students' Involvement

Lidia BORGHI, Anna DE AMBROSIS and Paolo MASCHERETTI
Department of Physics, University of Pavia,
Via A. Bassi 6, I-27100 Pavia, Italy

Abstract. A multimedia learning environment developed to help high school students deepen the study of hydrostatics is presented. Experimental activities and use of a hypertext connected with experiments lead students to grasp the concept of pressure and to explain the phenomenology related to transmission of forces in liquids. In the framework of our research, the work carried out with in-service teachers and their students on the use of multimedia tools and electronic communication is summarized.

1. Introduction

Research in physics education in Italy aims at improving scientific education and is grounded on a well-established tradition of cooperation of researchers operating in different Universities (1). The main effort is devoted to promote innovation by helping teachers to devise new teaching methods and to take full advantage from the use of new technologies with their students.

Since 1996 national projects were started by researchers in different Italian Universities, funded by the Italian Ministry of Education and by the National Research Committee, with the common aim of designing and testing models for the training of in-service and pre-service physics teachers as well as of exploring how new technologies can support teaching and curricular innovation. Particular attention is devoted to the pedagogic use of tools like MBL (Microcomputer-Based Laboratory) material, Videopoint, Interactive Physics, Excel, and Information and Communication Technologies (2).

A common feature of research done in different universities is direct connection with experimentation in the classroom carried out by teachers involved in research and the possibility of investigating the influence of teaching innovation on students and the role played by new technologies in their engagement.

An example of research carried out at the University of Pavia with high-school teachers and their students is briefly presented in the following paragraphs.

2. Method of work with teachers and students

We developed together with a small group of teachers (six) a work, starting from a discussion on the problems of students in the study of hydrostatics, proceeding with the analysis of a teaching proposal (prepared by our research group), planning the class work, reflecting on students' reactions, and ending with a revision of the teaching strategy and instruction material employed.

The work was based on the following interactions:

- researchers-teachers in periodical meetings, in which the subject knowledge was reconsidered in the perspective of making it appropriate for teaching, experiments were carried out, teaching proposals were critically analysed and a teaching strategy was planned as a common task;
- researchers-teachers via e-mail, in the period between the meetings, while teachers reflected on the work done, reconsidered the material proposed, and prepared a plan of the work to be carried out with their students. Then, when the class work was going on, teachers regularly exchanged messages to report on their activity with the students, on the actions undertaken and on perceptions of students' reactions;
- students-students and students-researchers, via e-mail. Students were asked to send short notes on their activities and to express their comments.

3. The study

The teachers involved in our research were particularly interested in exploring how the use of computers could support their teaching to students 14-16 year old. We proposed to deal with hydrostatics and to consider the use of a multimedia hypertext, prepared by our research group, and electronic communication.

Initially, we analysed together the approach employed by the teachers to introduce hydrostatics and the research findings on the difficulties of students on the subject (3-10).

It appeared evident that their presentation of hydrostatics widely reflected the pattern suggested by textbooks: it was essentially descriptive and based on the three principles (Archimedes, Stevino and Pascal) without attempts to relate one principle (especially Pascal principle) to the others. Moreover it was based on an intuitive concept of pressure, generally formalized using examples related only to solids. This approach does not help students to understand the idea of pressure inside a liquid.

The teachers analysed also textbooks widely used in Italian high school and their analysis showed that often texts do not focus on the points where students meet the difficulties documented in literature. Our conclusion was that results of research in physics education are generally disregarded in Italian standard textbooks.

4. The approach

In our meetings we proposed teachers to experiment the same approach they were expected to use with their students. For this they carried out simple experimental activities designed to promote in the classroom observations and discussion on the behaviour of liquids. Examples of objects and materials utilized are represented in Figure 1.

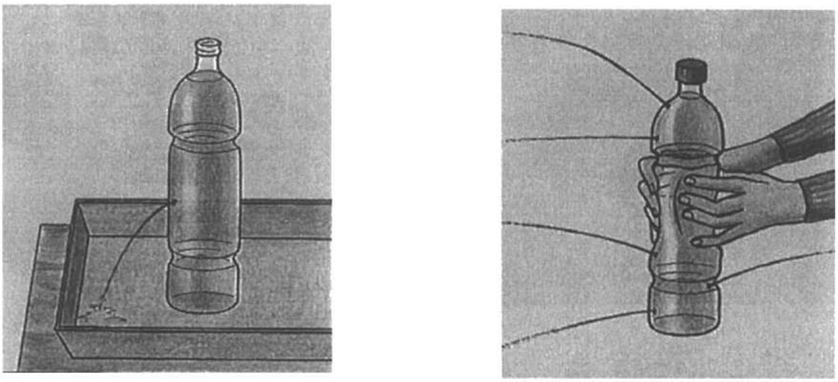


Figure 1. The jets reveal that water is under pressure: due to gravity (at left); due to action on the surface (at right)

The multimedia hypertext was prepared to favour the process of formalisation. It offers, in fact, students the opportunity of using animation and films designed specifically to let them reflect on their experimental activities and to provide formal representation of the physical quantities (e.g. forces) essential to describe and to explain the observed phenomena.

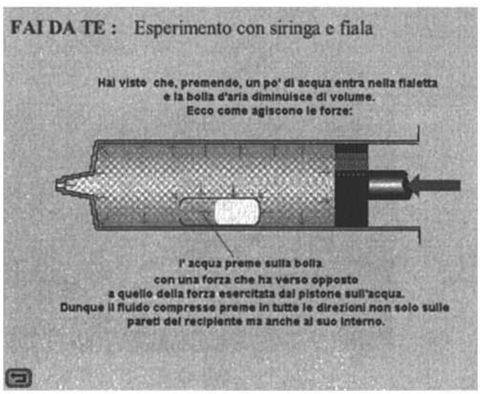


Figure 2. Compressing water in a syringe containing a vial with air inside.
Animation shows the forces acting on the walls and on the air bubble

In particular, as the hypertext helps students to pass from perception and observation of a system to the analysis of its components and their representation, it can be a tool capable of enhancing the students' interest and a cooperative engagement in learning.

5. A model to understand Pascal's Principle

In order to give students a chance to organise their ideas and representations in a structured and reliable frame, a model of a liquid is proposed both by means of real objects and of animation. The model we propose uses, in its most simple configuration, three small disks, as Figure 3 shows.

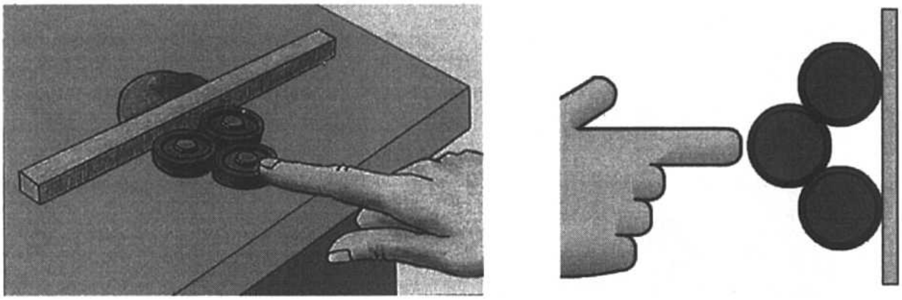


Figure 3. Disks are used to suggest the idea of "fluidity": three pieces (at left); animation (at right)

When a piece is subjected to a force, it exerts forces on the others which are perpendicular to their surface at the contact points: the two pieces move apart. The real situation is presented by animation. When the pieces are in a container, pushing a piece produces displacement of the lateral walls due to forces transmitted by the other pieces (Figure 4).

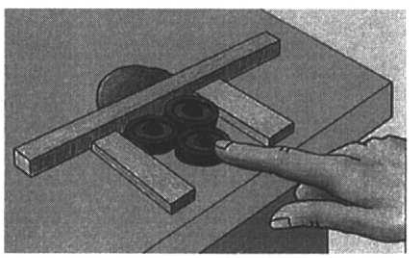


Figure 4.

Animation shows that the transmitted forces are perpendicular to the walls (Figure 5).

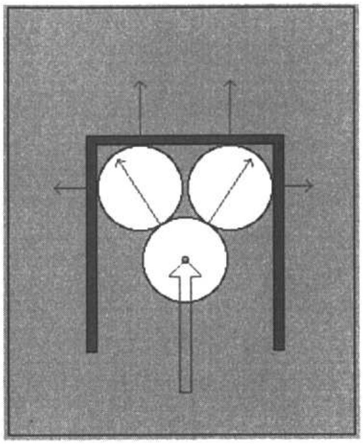


Figure 5. Three disks in a container: forces transmitted on the walls

Despite its simplicity, the model suggests how fluidity leads to compression when movement of a liquid is restricted. When a liquid within a container is subjected to external forces, it exerts forces perpendicular to the walls. Figure 6 shows an image from the hypertext in which a higher number of disks are compressed.

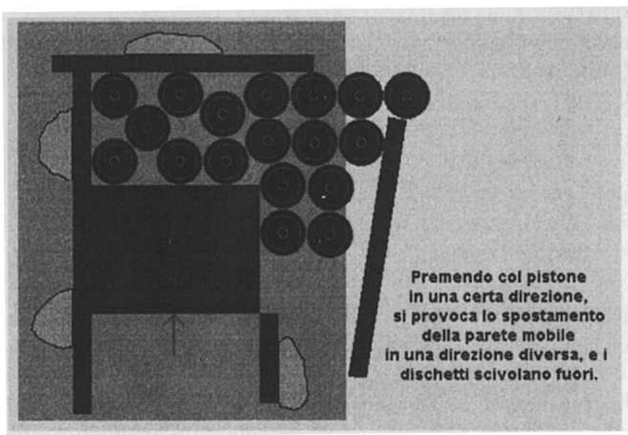


Figure 6. Animation of a model using a higher number of disks

A force exerted on the piston produces forces on the walls through the disks: it is shown by the flow of disks through the movable wall. With animation, up to fifty disks can be considered, both in an ordered configuration and in a disordered one and the distribution of forces on the walls, due to the action of the disks when an external force is applied to a row of them, can be visualised. Students can then see how disorder produces uniformity of the forces acting on the wall as each disk pushes on its nearest neighbours. The forces act along different directions, without a pattern. Thus averaging of forces takes place from the first row to the walls (Figure 7).

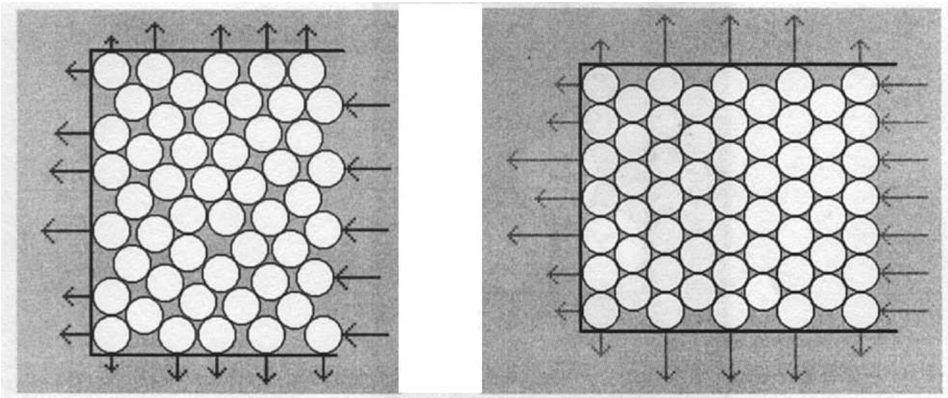


Figure 7. Distribution of forces on the walls transmitted by an ordered configuration and by a disordered one

In order to show how disorder increases as the number of elements becomes greater, lead pellets inside a "bi-dimensional box" (the pellets are confined on a plan by means of a glass surface) are used. The student can realise that this real system is spontaneously disordered and, by analysing it with animation, can recognise that, by pressing the pellets with a piston, a uniform distribution of forces on the walls is obtained. In fact, the disordered setting of pellets removes any memory of the original direction of the external force. Forces perpendicular to the walls are still exerted because any interaction between a pellet and the wall does not depend on the total number of pellets.

Starting from the idea that forces on the walls are uniformly distributed, the pressure exerted by a liquid on the walls is defined and it is shown how to define it also in any point within the liquid. This conveys the idea that pressure is a parameter describing the condition of compression within the liquid.

We give hints about the method followed. The liquid is visualised as being composed of layers. The balls touching a wall push on it because they are pressed by the layer of nearest neighbours and this is true for each layer, passing from the wall towards the interior. When the layer of balls touching a wall pushes on it, the wall necessarily reacts with an opposite force. This reaction is transmitted towards the interior causing compression of each layer by its near neighbours (Figure 8).

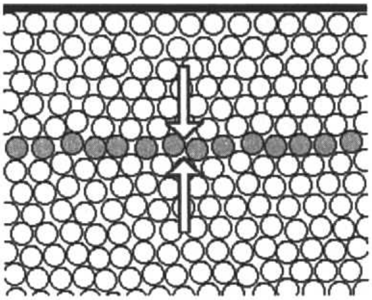


Figure 8. Forces on a layer within the liquid

In this way, attention is focussed on pressure "inside" a liquid, a fundamental idea to explain fluid behaviour.

6. The effects of gravity

Understanding Pascal's Principle is essential in studying the behaviour of a liquid under the action of gravity. In our proposal a mutual integration of experiments, carried out with simple apparatus, and work with multimedia helps students to recognise how gravity produces pressure within a liquid and that pressure depends only on the distance from the free surface. A qualitative approach is shown in Figure 9.

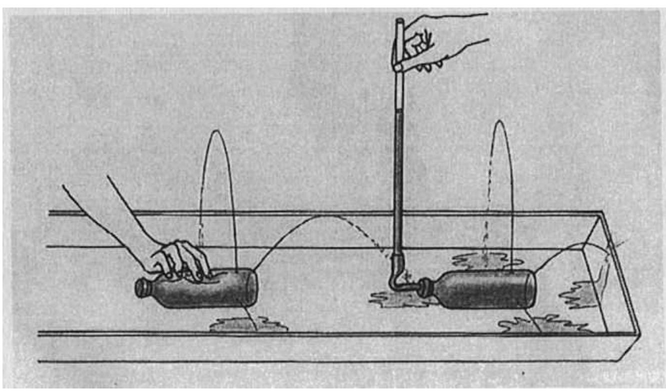


Figure 9. Studying the effects of gravity:
the water column produces pressure in the bottle as the hand does.

The hypertext proposes students to evaluate the pressure inside an "ideal container" due to the water in the column, and helps them to generalize the result to vessels of any shape (Figure 10).

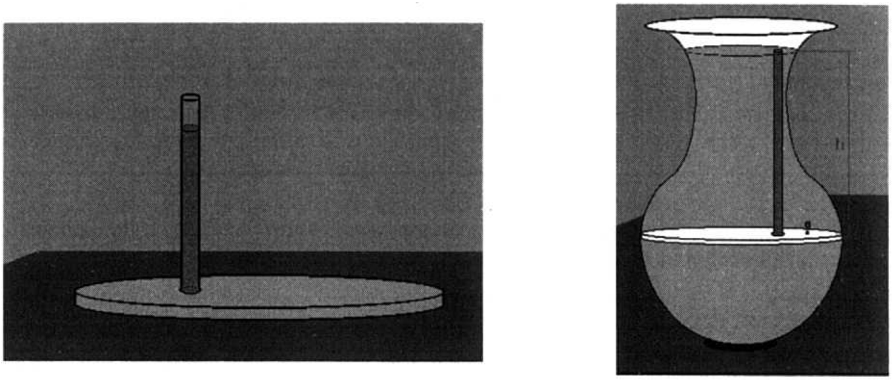


Fig. 10. Evaluating pressure in a thin layer of liquid at a given depth

An apparatus for a quantitative experiment to find the Stevin's law is shown in Figure 11.

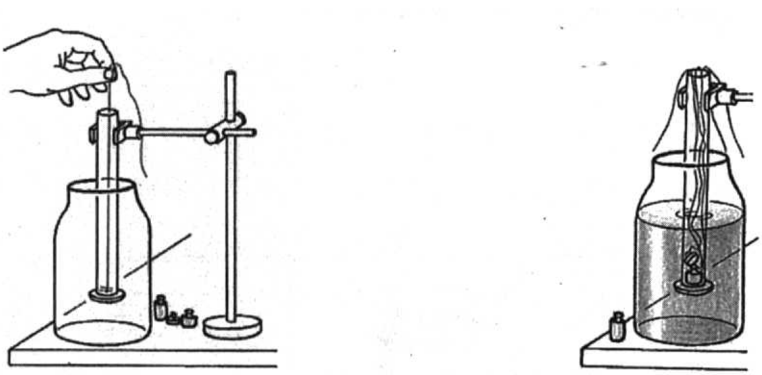


Figure 11. Forces due to pressure in a liquid hold the diskette as the hand does.

With animation, the distribution of forces inside the liquid and on the walls can be explored. Each wall of the vessel (or the surface of a submerged body) is subjected to forces which are always perpendicular to it, according to Pascal's principle. Stevin's law gives the pressure at any depth and allows to calculate the intensity of the force acting on a given surface. Figure 12 shows the force on a portion of a wall due to a liquid in a container and the distribution of forces on the whole surface.

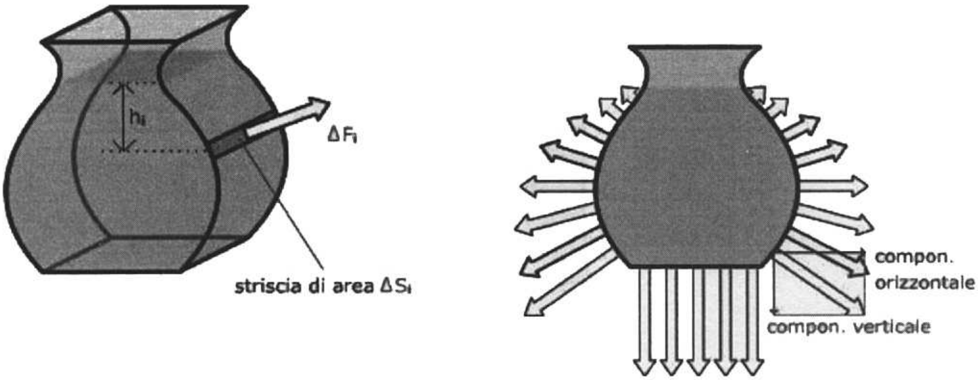


Figure 12. Force on a portion of wall due to the liquid (at left); distribution of forces on the surface (at right).

Students confirm their ideas with exercises involving a graphical representation of pressure and forces on the walls of containers of different shapes, by taking into account also the role of atmospheric pressure. Attention is drawn to general features of forces acting on walls. In particular, it is shown that the total force on the whole surface is vertical and equal to the weight of the liquid.

Analysis of vessels which are not cylindrical leads students to draw correctly the direction of forces exerted by a liquid on the walls (hydrostatic paradoxes are generally due to misunderstanding of this point).

In our approach Archimedes' law is presented as a consequence of Stevin's law and of the fundamental properties of liquids expressed by Pascal's principle.

In fact, the forces acting on an immersed body are analysed by dividing the body into thin horizontal and vertical layers. It is possible to conclude that the horizontal total force due to the liquid is zero and that, consequently, the hydrostatic force is vertical. The value of this force is obtained by considering the forces exerted by the liquid on vertical layers of the immersed body (Figure 13).

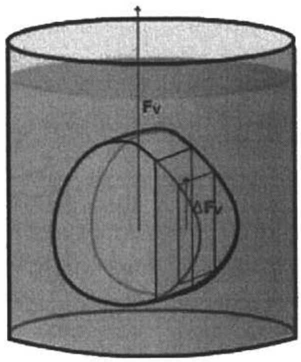


Figure 13. Forces exerted by a liquid on vertical layers of an immersed body

Animation helps students to realise that the value of the total force acting on the immersed body is equal to the weight of a volume of liquid equal to the volume of the immersed body.

7. Experimentation in Secondary School

A first trial of our approach in six classes of secondary school with students aged 14-16 years has been carried out by the teachers co-operating with our research group. In order to inquire students' ideas about fluids and pressure, an initial test was proposed; then, a final test was administrated to evaluate the effectiveness of our approach. All responses were analysed with a phenomenographic method (11-13) and the results indicated gains in students' performance.

Teachers confirmed that working in groups with the hypertext highly encourages interaction, integration and cohesion of the groups. In particular, interaction between students of different abilities within a group seems to stimulate development and innovation in the entire group. The bases for group membership move from physical proximity to communality of activity in addressing the study of the proposed subject. For example, students were engaged in a wide discussion, mostly by e-mail communication, on the models proposed in the hypertext. The interest devoted to modelling allowed students to recognize that every model has a limited validity of application. Precisely, as our model of liquid does not consider particle motion, it can not explain diffusion, solubility and thermal phenomena such as evaporation. Teachers considered it very significant that students appeared engaged in discussing, by e-mail, on points concerning their learning activity.

Other comments of teachers, taken from a questionnaire, revealed as effective, in our teaching proposal, the following aspects:

- the relevance of the subject;
- the plurality of approaches used to deal with the subject;
- the variety of experiments and material available;
- the use of models of a liquid built with real objects, visualised and analysed by means of multimedia;
- the attention given to the idea of pressure inside the liquid, and the reflection work on this concept that the hypertext helps to develop in detail.

8. Conclusions

Traditional teaching methods usually do not help students to consider the distribution of forces inside a liquid and to ground the definition of pressure on a representation which they feel as their own. Since the concept of pressure plays the role of a powerful cognitive organiser in explaining liquid phenomenology, we tried to design a strategy in which an integrated use of experiments and animation provides the students with the opportunity to gradually build their ideas about pressure.

The attention given in our proposal to simple experiments on liquids carried out by the students originates from the belief that observation plays a fundamental role in physics learning. Future evolution of laboratory activity of students in physics courses will largely depend on the development of today's technologies, included those which allow experiences of virtual reality. The complexity of this type of learning environment, and the fact that students will interact more and more with representations of reality, suggests that it will be essential for them to base their knowledge on a direct observation of physical phenomena. This initial step of learning path, referring to observation, in our opinion, should play in the future a role even more essential than today (14).

On the other hand, a positive interaction between students' disposition and multimedia environment is confirmed by our work with in-service teachers. With reference to the role of e-mail communication, the experimentation revealed that, beside being a vehicle for personal exchanges, it can be also a tool to engage students in cooperative learning.

9. Acknowledgements:

The research was funded by M.U.R.S.T. (Ministry of University and Scientific Research) and by C.N.R. (National Research Committee).

References

[1] P. Guidoni, Explaining and understanding in physics. In Roser Pinto (ed.), Physics Teacher Education Beyond 2000, ELSEVIER, Paris, 2001, pp. 245-248.

[2] R. Sperandeo-Mineo, I.MO.PHY. (Introduction to MOdelling in PHYsics education): a Netcourse supporting teachers in implementing tools and teaching strategies. In Roser Pinto (ed.), Physics Teacher Education Beyond 2000, ELSEVIER, Paris, 2001, pp. 135-139.

[3] M.G. Séré, A Study of some frameworks used by pupils aged 11 to 13 years in the interpretation of air pressure, *Eur. J. Sci. Educ.* **2** (1982) 299-309.

[4] E. Engel and R. Driver, What do children understand about pressure in fluids, J. Res. *Technol. Educ.* **3** (1985) 133-143.

[5] S. Ruggiero *et al.*, Weight, gravity and air pressure: Mental representations by Italian middle school pupils, *Eur. J. Sci. Educ.* **2** (1985) 181-194.

[6] M. Rollnick and M. Rutherford, African primary school teachers - what ideas do they hold on air and air pressure?, *Int. J. of Sci. Educ.*, **12**(1), (1990) 101-113.

[7] K.C. De Berg, Students' thinking in relation to pressure-volume changes of a fixed amount of air: the semi-quantitative context, *Int. J. of Sci. Educ,* **74**(3) (1992) 295-303.

[8] P. Kariotogloy *et al.*, A constructivist approach for teaching fluid phenomena, *Phys. Educ.* **28** (1993) 164-169.

[9] M. Rollnick and M. Rutherford, The use of a conceptual change model and mixed language strategy for remediating misconception on air pressure, *Int. J. of Sci. Educ.* **15**(4) (1993) 363-381.

[10] G. Bonera *et al.*, Comment on the article 'A constructivist approach for teaching fluid phenomena, *Physics Education*, **30**(5) (1995) 263-264.

[11] G.Dall'Alba *et al.*, Textbook Treatments and Students' Understanding of Acceleration, *Journal of Research in Science Teaching* **30**(7) (1993) 621-635.

[12] A. Stephanou (1997). Using the Rash Model to Study Large Scale Physics Examinations in Australia. Proceedings of the Ninth International Objective Measurement Workshop (http://mesa.spc.uchicago.edu/iomw.htm).

[13] E. Walsh, Physics Students' Understanding of Relative speed: A phenomenographic Study, *Journal of Research in Science Teaching* **30**(9) (1993) 1133-1148.

[14] G. Bonera *et al.*, Physics laboratory yesterday, today and . In Bernardini C., Tarsitani C. and Vicentini M.(Eds.) Thinking Physics or Teaching, Plenum Press, New York, 1995, pp. 139-143.

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

What do Gifted Children Think about the Quality in Education

"There is nothing more unequal than the equal treatment of non-equals" T.Jefferson

Jasna Cvetković LAY
Center for Gifted Child Development "Bistrić"
Zagreb, Croatia

Abstract. The results of researching on sample of 40 students of primary (7th and 8th grade) and secondary schools in Zagreb who are the best in computer education show us the great disproportion between their special educational needs and the opportunities which schools gives them. The students were tested with psychological tests (Intelligence Tests, and Emotional Profile Test) to check their intellectual abilities and leadership traits. The aim was to select the best of them for instructors in computer education in various kinds of extra school activities (summer camps, science and research specialized courses, workshops etc). It was the part of bigger Project of monitoring and guidance of the gifted children and youth in natural sciences aimed on selecting the gifted students from school competitions on local and the state level in order to established the relevant data base and organize various extra school activities with them and for them. Also, the aim of this project is to connect this significant national human recourse with potentially future employers in governmental strategy for 21. century in Croatia.

1. Introduction

There are number of reasons why we need to assist gifted students to reach their maximum potential. No doubt, they are a group with unique needs that most standard school programs in Croatia do not meet. Many researches in the field - Gifted and Talented Education - like Davis and Rimm (1), Feldhusen *et al.* (2), Gardner (3) offer rationales for educational systems to provide for gifted students needs in order to reach the better quality in education and better public understanding of gifted:

- Gifted and talented students have special educational needs and special emotional problems, but they also have special, sometimes immense talent to lend to society. We owe them to help cultivate their abilities; we owe it to society to help prepare tomorrow's *opinion leaders* and *professional talent*. Gifted and talented students are *tremendous human resource*, one that can not be squandered. Human recourse management of special sort should be established and developed for gifted.
- All the political and social systems based on democratic principles seek to provide an equal educational opportunities for all children. That is all right, but it is also

undemocratic to deny gifted children the right to appropriate educational development. We have to ask our governments: why do we still don't have the *National Program for Gifted and Talented Education*, as other developed countries have?

- Research suggests that when gifted, highly able children are limited and restricted in their development, when they are not allowed to move or to reach beyond, they often become bored, frustrated and aggressive. Those behaviours are the roots of possible future maladaptation, social deviation and etc.
- Elitism is related to giftedness only if one wrongly describes the group of gifted children as «group chosen because of some special skill or ability», which, if fostered, could become truly outstanding such as athletic skills, musical talent or business acumen. Our society values and rewards superior physical abilities; it should view intellectual giftedness in the same way.

Generally speaking, will it be possible to enter in 21st century, and would high-technology be without the gifted? How, then, to "catch the best place" in world-wide intellectual competition for economic survival without creative, able, talented people?

2. Definition of the Problem: some Crucial Questions

According some assessments we are late about thirty years, related to developed countries in organizing an efficient *network of caring for the gifted*[6]. We may think that this is wrong assessment but we still do not have the answers on very important questions for the future strategy of quality in education, talent recruitment and public understanding of gifted, such as:

- Do we have the precise information (*database*) how many children are very able, exceptionally able, gifted and talented in our schools and kindergartens. What kind of skills and abilities, what *kind of giftedness* are we talking about?
- How many gifted children attend some *special (differentiated or enriched) program?*
- What exists as *legislative regulation* for identification and provision of gifted?
- Do teacher have an *extra training* in field of gifted education?
- What kind of *professional support* do we offer to the parents of gifted children?
- Do we have some foundations and *material resources* for establishing gifted children special program?

A supporting network (professional and scientific institutes, organizations, associations dealing with the gifted) is necessary and crucial precondition for establishing some standards of quality in education. Besides that other features are important:

- Early identification and provision.
- Regular teacher education and extra teacher education (in service teacher trainings) in the field of Gifted Education.
- Attitude of expecting excellence from all children ("Do your best" teachers' attitude). Or the educators' attitude: "Emphasizing achievement, achieving excellence".

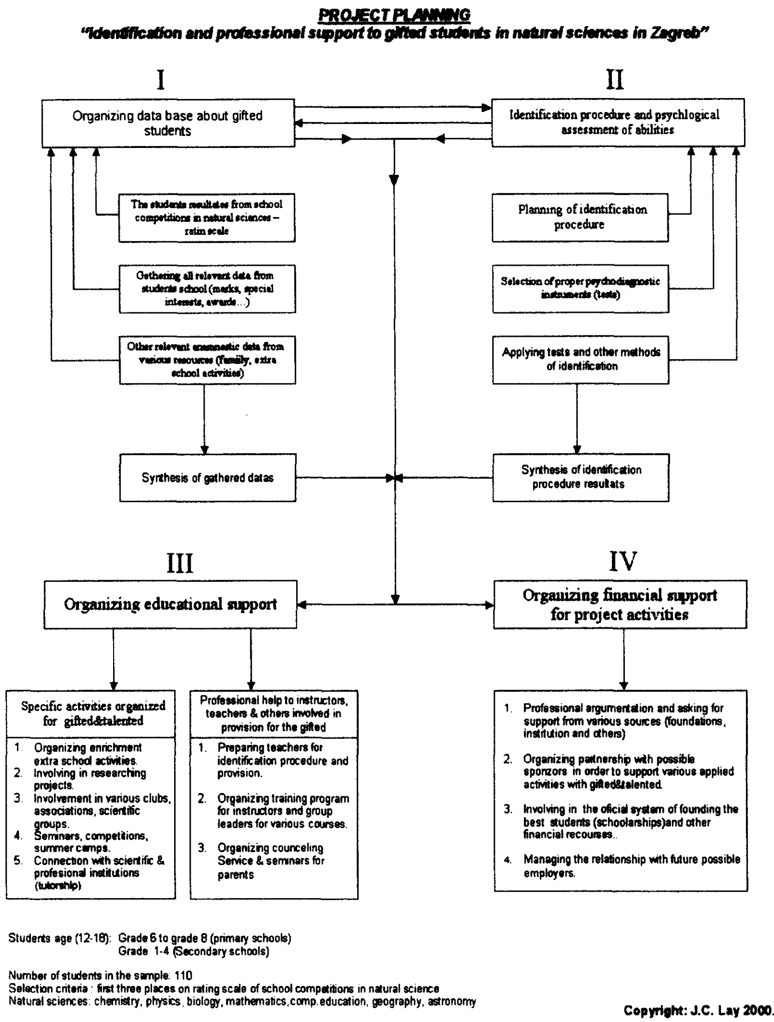
---

[6]It is related to the countries in transition, according the conclusion of international conference "National Networks for Gifted Children", Rovinj, Croatia, 2001. organized by Center for Gifted Child Development, Open Society Institute Croatia, Zagreb City Office for Education and Sport and supported by ECHA.

- Stimulating the development of creativity, enterprising and invention in society.
- Counseling and education aimed at changing the prejudices (usual "myths") about gifted children in society. Support their basic right "to be different".

3. Project of monitoring and guidance of the Gifted Children and youth in natural sciences

This project, which is in this moment in course in Zagreb is sponsored by the Zagreb City Office of Education and Sport includes a sample of over a hundred elementary and secondary school students in Zagreb, who won the first three awards in county contests in natural sciences. The basic goal of the project is to organize different educational and material support models for the gifted and to connect them with different sponsors and future employers (4-6).

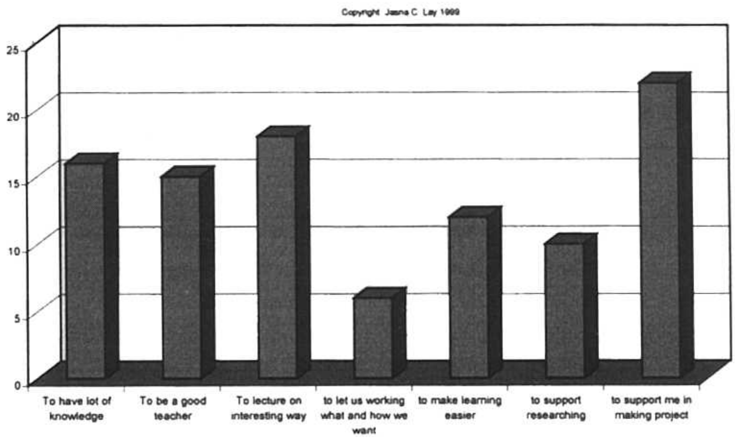


4. Results of Researching in Computer Education

4.1. Short overview on the Questionnaire

The sample were students nominated by their PC education teachers from 100 schools (elementary, secondary) in Zagreb as the best in that subject. They fulfill the short Questionnaire (http://skola.sys.hr). Almost all of students in sample have the computer in their home (91.6%) from the early years. Some of them (8.3%) from the age of 3, and all the others usually have the PC from the age of 7 (start of primary school). Four students in the sample with the high abilities (the highest scores on the test) got the PC latter (between the age of 10-12). 75% of those students have Pentium 133-450 MHz with additional components. Only 42% of them have modem. Six of best students in the sample do not have a modem! Only 5 % of students did not have any kind of knowledge about PC's before they start with PC education in school. It is interesting that two of those students, with the best results on Intelligence test got the PC very late, in the age of 12.

Table 1
Gifted children assessment of positive teachers' characteristics



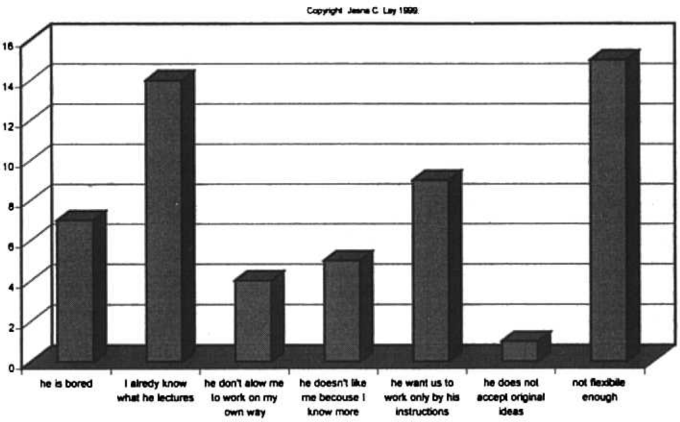
Student assessment of their PC education teachers are displayed in Table 1 (4-6). Key results are:

- *To support me and allow me independent work on projects;*
- *To give the opportunities for diversity in learning and to prepare lessons on interesting way (not boring) ;*
- *To have a wide knowledge in their field.*

These interesting assessments of gifted students undermine our prejudice about children (especially gifted children) that they are most happy when we let them to do what they want (give them "freedom"). As we see from the Table 1 the lowest rating was "to let us working how and what we want".

This range of choices confirms clearly some of well - known special characteristics of gifted children:

- The capability for independent learning. Project teaching is the most useful way to satisfy this need.
- High level of demands on the quality of teacher. They need not only a mastery of knowledge in subject, they should be able to teach interpersonal skills. Personal characteristics of the teacher are also important.
- Strong need for students to be guided (but very professionally and democratically!), not to be only on their own. To have a positive educational influence on gifted students means having high level of flexibility, self-consciousness, as well as the capability to learn from the gifted students and to involve them actively in creating the program.



Negative assessment of teacher's characteristics by frequency of choices, Table 2:

- *Rigid (not flexible enough) in program realization.*
- *I already know most of the thinks he lectures us on.*
- *He wants us to work exactly according to his instructions.*

These opinions of gifted students confirm us well-known fact about the greatest problem in our educational system: the lack of flexible, individualized, differentiated program and teachers' approach to the students of different abilities. There is a great gap between the special educational needs of very able children and teachers' approach. One student illustrates that with a few sentences: "*Old, bored, stiff professor is the worse think that can happen to the student who wants to learn something. We need young professionals. It is not only necessary to be master of knowledge, but to be willing to collaborate with students. I like professors who do not abuse their authority to hide ignorance.*"

90% of gifted students think that they can learn efficiently mostly at home. It confirms other results of research in that field: gifted students learning skills are different- they want to learn independently and they enjoyed the process of learning not only in school. We only have to create circumstances and to support independency (4)!

52% of our gifted students prefer independent ways of learning. They suggest the following reasons for that choice:

- *they are much more creative and original,*
- *recognize failures much faster,*
- *have the opportunity to do the things on their own way,*
- *nobody interrupts their thinking,*
- *have better working concentration.*

47% of gifted students chose team work (small groups or pair) and the reasons are following:

- *when we are together we can make "miracles",*
- *two people are smarter than one,*
- *we can exchange opinions/ideas and make better program,*
- *it is more amusing and creative.*

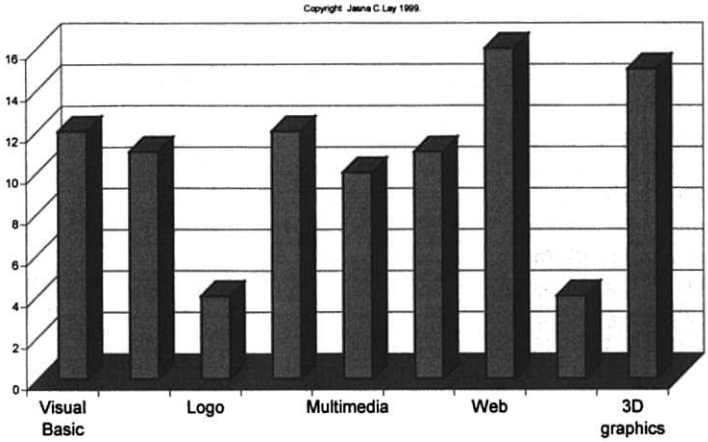
Again, this confirms the well-known characteristic of gifted students who prefer independent learning, initiating projects, innovating... and the necessity to change the strategy in education. Gifted students think that some of the following items will lead to improvements:

- *better equipment and material resources*
- *more time and greater freedom in working on the subject*
- *more efforts and better motivation (from themselves)*
- *literature (books, handbooks, professional magazines)*
- *more support and motivation (from teachers)*
- *different approaches of teachers (to program, to students)*
- *more practical examples*
- *smarter professors*
- *differentiated/enriched program*

Outside - school factors are positively rated as well, such as:

- *knowledge of language (mostly English)*
- *contacts with experts*
- *courses, associations, summer schools*
- *internet/ various guides on internet*
- *books and magazines*
- *independent problem solving on PC's*
- *independent research and information retrieval*
- *extra classes in PC education*
- *preparing for competitions*

Table 3
Interests of gifted children



Specific interests of gifted students in PC education are shown in Table 3. Obviously they prefer web site construction and 3D graphics. It is compatible with the view that we have to offer them more project teaching and stimulate their creativity.

5. Summary of Results

Besides teacher nomination we applied two tests: Problem solving test (form A) (Z. Bujas, S. Szabo i V. Kolesarić) and PIE: Emotions Profile Index (Plutchik and Kellerman). The results of Problem Solving test confirm that we have an appropriate sample regarding intellectual skills. The average score for our students was for 8.2 points better then the average score for students a few years older! We selected the first five best students in problem solving test with a stable emotional profile who preferred team work to prepare them as instructors on various extra school activities.

6. Conclusion

To reach better quality in education and better talent recruitment means not only better material resources, but more important, better human and psychological circumstances – a more stimulating environment for growth and development of talent: better motivation, better education of teachers and differentiated/enriched program.

One of the biggest problems in contemporary education is the problem of not enough challenging programs, and the problem of students who are smarter than their teachers.

We urge extra education for teachers and a better approach to gifted and talented children. Global change demands a new strategy for the gifted since they are very important human resource. Future education will have to promote creativity, invention and socialization on global world level including the Internet.

References

[1] G.A. Davis, S.B. Rimm, *Education of the Gifted and Talented*, Prentice Hall, Englewood Cliffs, NJ, 1989.

[2] J. Feldhusen, J.Van Tassel-Baska, K. Seely, *Excellence in Educating the Gifted*,: Love Publishing Company, Denver.CO, 1989.

[3] H.Gardner, *Frames of mind*, Basic Books, New York, 1983.

[4] J. Cvetković-Lay i A. Sekulić-Majurec, *Darovito je, što ću s njim?"*, Priručnik za odgoj i obrazovanje darovite djece predškolske dobi, Alinea, Zagreb, 1998.

[5] J. Cvetković Lay, *Daroviti informatičari – kako dalje?*, mini-istraživanje, «Bistrić», Centar za poticanje darovitosti djeteta i ZRS, Zagreb, 1999.

[6] J.Cvetković-Lay (editor), National Networks for Gifted Children, International Conference Proceedings, Open Society Institute, Center for Gifted Child Development «Bistrić» and City Office for Education and Sport, Croatia, 2000.

Session IV

Scientific Research Training

This page intentionally left blank

Howard Hughes Medical Institute Sponsored Student and Teacher Internship at the National Institutes of Health in Bethesda, Maryland, USA

Sandra R. SHMOOKLER
Montgomery County Public Schools
850 Hungerford Drive, Rockville, MD 20850, USA

Abstract. In 1990 the Montgomery County Public School (MCPS) system initiated Student and Teacher Internship Program as a pilot project designed to encourage educational advancement in science and increase opportunities for motivated high school students to perform hands-on scientific research under the direction of experienced mentors. The program is now in its 12th year. Each year 10 teachers and 18 high school students serve as interns in laboratories at the NIH after completing a two-week intensive biomedical technology course.

1. Background of the Student and Teacher Internship Program

The Howard Hughes Medical Institute (HHMI) provides financial and logistical support for science education opportunities for students and teachers in the Washington, D.C. metropolitan area, particularly in Montgomery County, Maryland, where HHMI is based. The Montgomery County Public School (MCPS) system receives the HHMI's largest local science education grant and uses these funds for its Student and Teacher Internship Program (STP) located at the National Institutes of Health (NIH) in Bethesda, Maryland.

STP helps students and teachers gain hands-on experience in biomedical research. The program helps students make academic choices and define career plans and goals. It also provides opportunities to publish original research in the biomedical sciences. Former interns report that the experience sparked their enthusiasm for a career in the biomedical sciences, and encouraged them to consider the possibility of earning an M.D. and/or a Ph.D. degree in the future.

In 1990, MCPS initiated STP as a pilot project designed to encourage educational advancement in science and increase opportunities for motivated high school students to perform hands-on scientific research under the direction of experienced mentors. Science teachers also were given the opportunity to perform laboratory research and to bring that experience back to their classrooms.

The original program in 1990-91 enabled two high school teachers and nine high school students to work in NIH laboratories and to serve as liaisons to their colleagues in elementary and middle schools. At the end of 1994, this program was opened to all students and teachers in the Montgomery County Public School system. Students no longer needed to originate from the same school as previous teacher interns.

An intern from the class of 1994 said that her experience at the NIH strengthened her interest in the sciences and taught her valuable laboratory techniques she would not have learned otherwise. She said that it also gave her insight into what a career in the sciences offers and encouraged her to pursue such a career. A 1997 intern, frustrated with his high school science curriculum, said the STP program stimulated his interest in the biomedical sciences and he is now pursuing a career in neuroscience.

The program is now in its 12^{th} year. Each year 10 teachers and 18 high school students serve as interns in laboratories at the NIH after completing a two-week intensive biomedical technology course. The students continue to work in the basic science laboratories for 20 hours a week during the school year. Teachers return to their classrooms with new ideas and activities. All teacher alumni are invited to return for professional development workshops given by current teacher interns.

Both student and teacher interns may return to the NIH for a second summer. Returning teachers are supported by a supplementary grant from the HHMI, and returning students are supported by funds from the NIH Office of Research on Women's Health.

2. The Preparatory Two-Week Basic Molecular Biology Course

The program begins the week that school is dismissed for the summer. The students and teachers work side by side during the two-week intensive laboratory course in basic molecular biology. NIH scientists give the major lectures, and former HHMI teachers lead the laboratory activities. Following are sample topics covered in the short course.

Bioethics
DNA Transcription and Translation
Agarose Gel Electrophoresis
Use of Medline
Polymerase Chain Reaction
DNA Sequencing
Laboratory safety
DNA restriction analysis
Role of animals in research
Protein structure and function
Presenting research data
Blotting techniques
DNA plasmid analysis
Bioinformatics

A follow-up assessment for the summer course allows the program administrators to gain insight into the most valuable components of the program and suggestions for improvement. Last year, most teachers and students thought that the most rewarding part of the course was the hands-on laboratory experience because it helped them develop confidence in preparation for their internship. The students and teachers also suggested that lecture time be reduced.

The pre and post course analysis of laboratory skills indicated gains of 7% to 93% in confidence with laboratory techniques.

3. The Research Experience in a Modern Scientific Laboratory

Students in this program develop skills and scientific understanding that can be applied to new situations and problem solving, and they acquire the ability to formulate and revise scientific hypotheses using logic and empirical evidence. They also improve their ability to communicate research results effectively in written and oral form and learn to formulate accurate and logical conclusions supported by research data. The internship program includes not only the research experience in the laboratory under the mentorship of an experienced science researcher, but also classroom participation that helps students prepare scientific papers and lectures. This is the first time most of the students are challenged to meet the professional and academic standards of the scientific workplace. These interns often work at graduate student level, performing the biology, chemistry and technology required to answer complex biomedical questions. The interns meet as a class twice a month to discuss their research with the program coordinator.

Two texts are used as background for these discussions:

- How to Write and Publish a Scientific Paper. 5th edition, by Robert A. Day
- Dazzle 'em with Style. The Art of Oral Scientific Presentations. by Robert R. H. Anholt

The class syllabus below demonstrates the pace of the program. The students are given two weeks to complete each half of their research papers. When the major part of the paper is finished, they begin to present their practice talks to their peers and scientist advisors. When the first round of talks is complete, students are assigned to a scientist advisor for one-on-one meetings to discuss their scientific methods, data collection and analysis, interpretation, and presentation of results.

HHMI 2001/02 PROGRAM OUTLINE

SEPTEMBER

SEPTEMBER 15:	Discuss research paper- "Introduction/Background" Read Chapter 7, pg. 33- "How to Write the Introduction" **Homework: E-mail 1st draft by September 29**
SEPTEMBER 29:	Peer Review - 2nd draft of "Introduction/Background" Discuss "Methods and Materials" Read Chapter "How to Write the Methods and Materials" **Homework: E-mail 3rd draft of "Introduction-Background", E-mail 1st draft of "Methods and Materials" Due date: October 20**

OCTOBER

OCTOBER 20:	Peer Review- 2nd draft of "Methods and Materials" Discuss "Results" Read Chapter 9, pg. 42 "How to Write the Results" **Homework: E-mail 3rd draft of "Methods and Materials" E-mail 1st draft of "Results" (May not have completed results but provide what you do have and what the lab expects for results) Due date: October 27**
OCTOBER 27:	Peer Review- 2nd draft of "Results" Discuss the statistics, visual aids, and oral presentation Discuss "Discussion" (conclusion) Read Chapter 10, pg. 45 - "How to Write Discussion" **Homework: E-mail 3rd draft of "Results", E-mail 1st draft of "Discussion", Due date: November 3**

NOVEMBER

NOVEMBER 3:	Peer Review- 2nd draft of "Discussion" Discuss oral presentation, visual aids, and summary/outline **Homework: E-mail 3rd draft of "Discussion", E-mail 1st draft of "Laymen Summary/Outline", Due date: November 10**
NOVEMBER 10:	Peer Review- 2nd draft of "Summary/Outline" Power Point presentation by Bill Becones Discuss oral presentation, visual aids, and scientist advisors **Homework: E-mail research paper (needed to give to scientist advisors for presentation), E-mail 3rd draft "Summary/Outline", Due date: December 1**

DECEMBER

DECEMBER 1:	1ST group oral presentation with visual aids (overheads) and "Summary/Outline"
DECEMBER 15:	2nd group oral presentation with visual aids (overheads) and "Summary/Outline"

JANUARY

JANUARY 5:	3rd group oral presentation with visual aids (overheads) and "Summary/Outline"
JANUARY 19:	All students must attend meeting to discuss "Abstract" Start working on 1st draft "Abstract" **Homework: E-mail 1st draft by February 2**

FEBRUARY

FEBRUARY 2:	3rd group oral presentation with visual aids **Homework: E-mail 2nd draft by February 16**
FEBRUARY 16:	2nd group oral presentation with visual aids **Homework: E-mail 3rd draft "Abstract" by March 2**

MARCH

MARCH 2:	3rd group oral presentation with visual aids **Fax final version "Abstract" TODAY --must be signed by preceptor**
MARCH 16:	1st group oral presentation with **slides (all students must attend)** **Homework:** Final research paper
MARCH 30:	**NO CLASS MEETING** FINAL RESEARCH PAPER DUE TODAY

APRIL

APRIL 6:	2nd group oral presentation with **slides (all students must attend)** Fax "Research Paper" with approval signature by preceptor.
APRIL 20:	3rd group oral presentation with **slides (all students must attend)**
APRIL 26:	DRESS REHEARSAL AT HHMI CONFERENCE CENTER

MAY

MAY 3:	**DINNER SYMPOSIUM AT HHMI CONFERENCE CENTER**

While on the NIH campus, the student interns have an opportunity to attend seminars, participate in laboratory meeting and collaborate with other scientists. The students are required to write a comprehensive scientific research paper and present a summary of their work at a dinner symposium attended by about 150 scientists, as well as family members, school administrators and political officials. This symposium is held at the HHMI Conference Center each spring.

The student report is written to prepare students for their presentations at the Dinner Symposium. This paper targets the mixed audience that typically attends these symposiums. It also gives the coordinator an understanding of the depth of understanding each student achieves in his or her research topic.

4. Howard Hughes Medical Institute Research Report Outline

A research report is a document that clearly and precisely communicates an individual's research experience in the laboratory. The objective is to focus the intern's thoughts on the scientific process of original biomedical research. The major guidelines communicated to student interns include:

1. The introduction should acquaint the reader with a scientific problem that has been investigated. It should include its implications and/or applications to the larger field of the biomedical sciences.
2. The design and research methods should be clearly explained. This includes materials and scientific protocols utilized to collect data.
3. The data should be fully and effectively presented in an organized manner for analysis. The data should substantiate all interpretations and conclusions contained in the report.
4. The discussion or interpretation of the data should demonstrate to the reader exactly how the data resolves (or fails to resolve) the problem that has been investigated..

Outline of the Required Research Report

I. Title page
II. Table of contents
III. List of tables and figures
IV. Acknowledgments
V. Introduction
    - Problem and its setting
    - Sub-problems
    - Hypothesis
    - Delimitations
    - Definitions of terms
    - Abbreviations defined
    - Assumptions
    - Need for the study
    - Organization of the remainder of the study

VI. Review of the Related Literature
    - Theoretical concepts
    - Historical background
    - Findings related to problem

VII. Methods and Materials
    - General protocols
    - Data collection procedure
    - Treatment of the data

VIII. Results
    - Test of the hypothesis
    - Reliability and validity
    - Summary of results

IX. Summary, Conclusions and Recommendations
    - summary of findings
    - conclusions supported by data
    - recommendations for future investigation

X. References

The tracking initiated in 1996 and 1998 via a student survey is being analyzed and updated. A self- reporting website has been developed to track students' advancement in their chosen career paths. A pilot survey in 1999 showed that 70% of those responding indicated that participation in the Student Internship Program (STP) positively affected their decision to pursue a career in the biomedical sciences. The program provided mentoring and guidance, reinforced interest in science careers, better prepared students for college and gave them first-hand experience with science careers. Of those surveyed 87% stated that the STP positively influenced their decision to major in biology, biochemistry, or to continue work in medical research.

5. Second Summer of Employment

The Office of Research on Women's Health generously provides funds to support successful HHMI students for a second summer of employment. This allows students the opportunity to present their work at conferences or to submit an abstract or paper for publication. This experience also bridges the transition to research opportunities at their universities. Each year, ten to twelve students receive a second summer of funding for the purpose of continuing their biomedical research. Former HHMI students from previous years are also invited to apply.

In the second summer of 2000, 90% of the students were able to publish their research in a professional journal. Publications usually go to press about a year after the students complete their second summer internship.

In 2001, a student intern won first place in his category in the prestigious Intel International Science Fair. In 2002, another intern was a finalist in the same competition.

6. Requirements for Student Applicants

This year long educational experience is open to MCPS juniors and seniors (grades 11 and 12) and is managed by the Department of Academic Programs and coordinated by the Office of Science Education (OSE) at NIH. The student internship is a demanding and extremely rewarding experience that is offered to 18 MCPS juniors and/or seniors who meet best the following criteria:

1. Maintain a grade-point average of 3.0 or higher
2. Demonstrate significant interest in a career in biomedical research
3. Complete Algebra 2, biology, and chemistry, or are taking Algebra 2 and chemistry concurrently
4. Have an excellent attendance record
5. Reach their 16th birthday on or before July 1 of the year of the internship
6. Are U. S. Citizens or hold a valid Green Card

Each high school may submit applications from four students. If more than four students from a single high school wish to apply, the school principal reserves final discretion as to which students will be invited to apply. Application worksheets are obtained from each high school's science-resource teacher, and applications are completed online. Completed applications must be submitted prior to the deadline date indicated on the application worksheet.

Students receive 5 honors academic credits when they complete the STP program. One credit is given for the summer portion of the program. An honorarium of $1,600 is paid in two installments for the summer portion of the program. During the first two weeks, students learn basic molecular techniques in a classroom course and the next 6 weeks are spent working full time in an NIH lab. Two academic credits are allotted for each of the two semesters during the school year. To receive credit, students must complete a research paper and give a scientific lecture at the HHMI Dinner Symposium in May.

7. Requirements for Teacher Applicants

This educational opportunity is also open to middle and high school science teachers. The program begins the Monday after the last day of school. It includes a two-week course in basic molecular biology techniques and then a 6-week lab experience at NIH. This program is intended for science teachers who:

1. Have completed a college-level course in chemistry
2. Have a basic understanding of molecular biology
3. Wish to learn how modern biomedical research is conducted
4. Want to spend a summer in an intellectually challenging research environment

To apply, **first time teacher interns** must submit an online application including the items listed below:

1. A personal statement detailing the ways this internship will enhance their teaching ability, contribute to their professional development, and define their commitment to share their research experience with other teachers.
2. A summary of courses completed in biology and chemistry, with dates completed and grades earned.
3. A recommendation from their principal.

Returning teacher interns spend 7 weeks in their NIH laboratories continuing their research. The remaining week is spent developing an instructional unit to be piloted during the next academic year. Teacher interns are required to give workshops to their colleagues based on this unit. The stipend for the 8 weeks is $800 per week.

Previous teacher interns must submit an online application including the items listed below:

1. A one-page description of an instructional unit they would like to develop by returning to a laboratory at NIH. This work is an extended laboratory unit lasting a week or more, including introduction, questions to be explored, and discussion of results, background material, and an examination.
2. A statement of the method to be used to train other teachers to use the unit with their

students.

3. A completed application endorsed by the teacher's principal.

Several former teacher interns are now teaching the summer molecular biology course for the program workshops for teachers throughout the academic year. This program greatly enhances the professional development of secondary school science teachers in the Montgomery County Public School system.

8. About the Howard Hughes Medical Institute

The Howard Hughes Medical Institute is a nonprofit medical research organization that employs hundreds of leading biomedical scientists working at the forefront of their fields. In addition, through its grants program and other activities, HHMI is helping to enhance science education at all levels and maintain the vigor of biomedical science worldwide.

The Institute is one of the world's largest philanthropies, with laboratories across the United States and grants programs throughout the world. Its headquarters and conference center are located in Chevy Chase, Maryland, near Washington, D.C. HHMI's endowment in 2001 was approximately $11.5 billion.

The Institute carries out research with its own scientific staff in HHMI laboratories at research institutions and academic medical centers across the United States. Using the powerful new tools of molecular biology, these researchers seek to discover the molecular and genetic basis of how the human body functions and why disease occurs. HHMI investigators have been involved in many recent advances, from the discovery of genes related to cancer, heart disease, obesity, cystic fibrosis, muscular dystrophy, and other diseases to new insights about how organisms develop, cells communicate or learning occurs.

The Institute is an operating medical research organization—not a foundation. This means that it carries out research with its own scientific teams. Currently, it employs about 330 HHMI investigators, all of whom also serve as faculty members at host institutions with which HHMI has entered into long-term collaborations. The scientists are supported by approximately 3,000 research associates, technicians, and other personnel employed by the Institute, as well as by a headquarters staff of nearly 200.

HHMI selects its investigators from among the faculties of universities and academic health centers around the country. It solicits nominations from these institutions, seeking to identify researchers with the potential to make significant contributions to biomedical science. Those selected as HHMI investigators are appointed for five- or seven-year terms, which may be renewed after rigorous review.. They meet regularly at HHMI's headquarters in Maryland to discuss their work.

By appointing scientists as Hughes investigators—rather than awarding research grants—HHMI is guided by the principle of "people, not projects." The Institute believes that science is facilitated best by providing outstanding researchers with the resources and flexibility to follow their scientific instincts and to pursue new opportunities as they arise.

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Mentoring Students and Teachers for High-Stakes Science Competitions

Bonnie KAISER
The Rockefeller University
1230 York Avenue – Box 53, New York, NY 10021, USA

Abstract. Scientific research is ideal science education for high school students, K-12 teachers, and the scientists who mentor them. Of the 468 students in Rockefeller University's Precollege Science Education Program begun in 1992, at least 71 were semifinalists in national or international science competitions such as the Intel, formerly, Westinghouse Science Talent Search. At least 40 of the 60 teachers created student research programs. And, scientists improved as mentors by working beside teachers in labs, classrooms, and the Program's ScienTific Reading And Writing course (STRAW). STRAW supports inquiry by teaching how to read journal articles, write research papers, and communicate science orally.

1. Introduction

High-stakes science competitions can motivate high school students to do research projects. They can also stimulate teachers to gain research experience in order to create research courses. However, they are not the only drivers for students, teachers, and the scientists who mentor them in Rockefeller University's Precollege Science Education Program (Science Outreach). Rockefeller is a graduate research institution. As such, graduate and postdoctoral fellows have no teaching obligations. And yet, scientists choose to contribute to the K-12 education community by mentoring students and teachers who want to learn science by doing laboratory research; and some volunteer as Scientists-in-the-Schools to work alongside teachers in their classrooms. All the Program requires is that novices have a threshold-level knowledge of science coupled with a high-level of self-motivation.

Science competitions do tend to organize research around projects designed to have a beginning, middle, and end. Even though research never truly ends, novices come to appreciate this fact while they also gain a sense of accomplishment by completing a body of research and communicating it to their peers. For, it is not science until it has been communicated to others. Some students who had not originally intended to enter science competitions do so and become semifinalists once they see the magnitude of their accomplishments by writing their research reports.

Outreach has a distinguished record with at least 71 semifinalists in national and international science competitions such as Intel, Siemens, the American Academy of Neurology's Neuroscience Prize, the United States Delegation at the International Youth Science Forum, the NAACP Afro-Academic, Cultural, and Technological Scientific Olympics, Duracell, the Intel Science and Engineering Fair, and at the State Level of the German Science Competition. It has produced at least 20 finalists and 6 winners in these science fairs and enjoys recognition in the press (1) and in publications by prestigious organizations such as the Howard Hughes Medical Institute (2-4).

Of the 60 students, ages 16-18, who are mentored each summer, 10% consistently become semifinalists. Moreover some are co-authors on peer-reviewed journal articles and 20% of the 468 students return at least once accounting for 580 *student summers*. Most all persevere in science majors and enter graduate school to prepare for biomedical careers. Four alumni, including two African Americans, are currently on campus either as a research assistant, graduate fellow, medical student, or biomedical fellow for the combined degree.

The Program does not use any special signifier for gifted and talented students but relies on transcripts, letters of recommendation, an essay, and an interview with the potential mentor to gauge eagerness and threshold-level readiness. Since 1992, nearly half of the students have come from 4 schools out of 127 overall. They are public schools known to attract gifted and talented students or have research classes, and they account for most of the semifinalists. Overall, 24 different schools contributed students who became semifinalists, including some for the very first time. Thus, the Program is creating opportunities for more students from diverse backgrounds to enter these high-stakes science competitions. Annually, about a third of the 60 students are disadvantaged and half are girls. Among the 71 semifinalists, nearly half were disadvantaged or girls.

Another way that Outreach creates opportunities for diverse students is through its Teacher Program. Since 1992, 60 teachers have accounted for 111 *teacher summers* where the average commitment is for 2 summers. Forty have created research programs in their schools or districts. Annually, about half of the 12 Outreach teachers educate significant populations of disadvantaged students. Teachers are treated as members of a professional learning community and are chosen partly for their potential to implement inquiry-based learning (5). They are matched with scientist mentors, present posters, and write research reports just as the students do. However, they also create action plans that describe *how* they will implement their research experience back in their classrooms, and they design workshops aimed at disseminating the Program's materials and methods among their peers.

Outreach is committed to helping all participants succeed. In 1998, the Program created the ScienTific Reading And Writing course (STRAW) as a way to help all Outreach students and teachers maximize their research experience by learning how to read scientific papers and write in the IMRAD style (Introduction, Materials and Methods, Results And Discussion). *STRAW addresses the fact that beyond gaining technical facility, scientific inquiry requires the ability to read scientific literature, write scientific papers, and communicate science orally using figures and graphs.*

This novel course is planned and taught by a team of three experts: a scientist, a teacher, and a returning Outreach student. They have overlapping roles but mainly, the scientist explains the content of the model journal article and why it is considered a *classic* in its field, the teacher helps novices translate their research into a report, and the returning student helps new students negotiate how to work in a lab. In just 6 weekly sessions totaling 12 hours, novices learn how to communicate their research using a standard scientific writing style.

STRAW is an excellent model for achieving inquiry-based learning. The Program recently added an evaluator who specializes in inquiry-based learning to help Outreach teachers adapt the STRAW model. She will help them internalize what inquiry looks like. She will facilitate inquiry learning in their classrooms and evaluate whether their students are learning by doing inquiry. The rationale for disseminating STRAW as a model for inquiry-based learning is based on the Program's success with Outreach students in achievement and retention in science. These outcomes are documented in longitudinal studies on Outreach students and in case studies on the students of Outreach teachers (6,7).

The Program's success with students, teachers, and scientists is creating a campus culture that is poised to do more for K-12 science education. However, the model of intense, one-on-one mentoring is not appropriate to the scale needed to reach whole classrooms of students and teachers. The first group of teachers suggested in 1992 that the University build a laboratory dedicated to Outreach. This year, the University is set to build a new research building. In celebration of Rockefeller University's 100th Anniversary in 2001 and reviving an idea from the founding in 1954 as a graduate school, this new building will have a Teaching Laboratory dedicated to serving the community.

2. The Scientific Reading And Writing Course Supports Mentoring

Since 1992, the Program has explored ways to help all novices progress quickly to a point where they understand the science driving their research enough to communicate it clearly using good scientific writing. Research reports, as works-in-progress, had always been required and mentors were content to ensure accuracy and acknowledge student contributions. However, mentors did not feel equipped to help students acquire the essential background in science writing skills and strategies needed to read journal articles for understanding. At the same time that the Program was looking for ways to improve the mentoring process, an Outreach teacher was meeting weekly on campus with students from his research class who were doing science fair projects at various institutions. Over a period of 2 years, he produced 16 Westinghouse semifinalists – an impressive success rate. Outreach was quick to copy his methods and invited scientists to facilitate the student sessions. In time, formal student presentations were added. Eventually, students became so polished that only their mentors could understand them. Students communicated details devoid of a rationale for why they were doing the research or why it was important. *They were missing the big picture*. The Program needed another approach.

From 1992 to 1997, 336 students participated. One fourth were underrepresented minorities and over half were girls. Of the 43 semifinalists, 20 were underrepresented *minorities or girls, including 8 of the 13 finalists, and 3 of the 5 winners. Thus, Program quality and diversity were being maintained.*

In 1998, an Outreach teacher of English returned for her second summer but expressed a desire to teach scientific reading and writing rather than return to a laboratory. She teamed up with a postdoctoral fellow who felt a critical need to teach students communication skills based on her earlier experience as a mentor. They created the ScienTific Reading And Writing course, STRAW. For her English classes, the teacher was used to teaching writing skills by borrowing from different disciplines such as anthropology, history, and science. For scientific writing, she used a simple book by Robert A. Day (8). The postdoctoral fellow chose a variety of scientific readings at various levels intended to appeal to students. STRAW 1998 articles concentrated on mimicry in fireflies. Two journal articles and others from the popular press were presented along with themes on natural selection. A Rockefeller professor facilitated final student presentations that emphasized speaking for public understanding.

In response to evaluations, STRAW 1999 used only one theme, genetic modification of food, but again from a wide range of publications and introduced the *National Center for Biotechnical Information* website. That theme, however, failed to have broad appeal. Too much time was spent reading and analyzing articles and discussing the Day book while not enough time was used for writing research reports. To be helpful, STRAW needed to engage students in reading articles pertinent to *their own* research and writing sections of *their own* reports. The scientist and the teacher also had different teaching styles. One gave lectures and sought questions from quiet students while the other used small group work, peer editing, and in-class writing with lively students. Same students – different behaviors. Having a noted scientist lecture or facilitate their presentations also proved to be successful.

STRAW 1998 and 1999 included 117 students. Of the 15 semifinalists, 6 were disadvantaged or girls, including 1 of the 4 finalists, with 1 winner. Thus, STRAW was supporting the research experience. It was also encouraging Outreach teachers to use original research papers in their classrooms with successful outcomes. The English teacher upgraded the articles she used with her students. Another used STRAW to create an AP Biology course in her school where over half of the students were underrepresented minorities. Four students enrolled and 3 took the AP exam resulting in 2 *5's* and a *3*. The next year, 8 enrolled and 7 took the exam resulting in 4 *5's* and 3 *4's*.

STRAW 2000 was trimmed to meet once a week for 90 minutes instead of 60, with a repeat session to accommodate everyone. Only the first two sessions were reserved for analyzing the one model journal article to teach strategies, content, and style. Students were assumed to understand the Day book on their own. Because the scientist was leaving to accept her first tenure-track position, a postdoctoral associate professor in the laboratory of Nobel laureate Günter Blobel assumed her role. STRAW concentrated on a seminal paper of Blobel's from 1975 that introduced the signal hypothesis and included two supporting articles with appropriate additions from a web-based textbook. Other web-based resources included the University's animation of the signal hypothesis showing the synthesis of a secretory protein as it is transported across a membrane.

STRAW 2001 was preceded by a teacher workshop that introduced the materials with *writing-to-learn* methods. Teachers then could concentrate on modeling STRAW methods and be more aware of classroom dynamics once the course started. Students entered the course the following week beginning with an analysis of the Blobel paper for *the big idea* and as a model to learn strategies for reading difficult material. They used small-group work to generate *understand/don't understand* lists of every sentence in the first paragraph of the Introduction. Each sentence was then discussed as a class to help illuminate the content and uncover misunderstandings. Next, they brought in a paper from their mentors and used the same dynamic methods to understand their various research projects. By mid-summer, students were discussing the rationales driving their research. Next, they presented schematic flow diagrams of their projects and edited each other's protocols. The following week, they were transforming their rationales into Introductions and adding references. They ended the summer by presenting posters for their peers, mentors, and parents and submitting research reports, as works-in-progress. Blobel also gave a mid-summer seminar on the signal hypothesis that included a personal history of triumphs and defeats.

*STRAW 2000 and 2001 included 127 students. Thirteen became semifinalists with three finalists. At this writing, the 2002 winners have not been named**. *Five of the semifinalists were disadvantaged or girls.* Evaluation of STRAW 2001 signaled a change for this summer's STRAW 2002 to a modern journal article with the criterion that it, too, be a *classic*. The teaching team had included a returning student who led discussions on how students felt about their experiences. Unfortunately, this took too much time away from learning content. The team-teaching model will remain but with more time for content and less for affect. Class will meet for six sessions but increase to two hours per session to include discussions of the Day book. Three scientists will team-teach with the English teacher. They are: (1) an Assistant Professor and Head of Laboratory, (2) her Graduate Fellow who is a former Outreach student and current mentor, and (3) the mentor's returning Outreach student. The article will focus on the Laboratory Head's doctoral research on the genetics of olfaction. Having the contribution of three, accomplished, female scientists at various stages in their careers should prove to be a most engaging way to convey the content and culture of scientific inquiry.

3. Conclusion

STRAW works because it results in a research paper after only six weeks whether or not novices have succeeded in gathering any useful data. The course solves the seeming paradox of writing about *something* when one has *nothing* to report. New and returning students learn from each other in an atmosphere that is relatively free of competition. Some of the returning students have already been semifinalists and accepted at the college of their choice so they are more willing to help younger students. Some are in the same laboratories or in research teams that include teachers. In addition to class discussions on their research, students also share their frustrations and triumphs and in the telling, learn that they are not alone. Furthermore, in her fifth summer, the English teacher became so comfortable in her role that she *created a welcoming high school classroom culture within Rockefeller's graduate research institution.* Her achievements illustrate how Outreach supports

* Note added in proof: One boy won first prize in computer science at the INTEL ISEF.

continuing professional development. In addition to being a classroom teacher, she recently was promoted to staff developer where she continues to influence other teachers and administrators, Rockefeller scientists, and college faculty who have begun to use STRAW in their college courses and teacher workshops.

Outreach exemplifies all of the standards for Professional Development of Teachers in the National Science Education Standards and, by aiming to infuse inquiry-based teaching and learning into K-12 classrooms, it also supports the Content Standards (9). Outreach with STRAW provides a good model to support two recent recommendations by the National Research Council; (1) that university faculty play a bigger role in continuing teacher professional development as the best way to improve teacher education and (2) that new Ph.D.-s be encouraged to teach (10).

Outreach continues to build on its core strength of intense, one-on-one mentoring. Gifted and talented students have helped lead the way, and their accomplishments provide encouragement as the Program strives to reach larger, more diverse populations. Annually, a tenth of the students excel in high-stakes science competitions and a fifth return. Most all persist in science majors and careers. Some are even accepted into Rockefeller's graduate programs. The Teaching Laboratory that will be used by whole classrooms of students and teachers might never have been contemplated were it not for the culture created and nurtured by Science Outreach (11-13).

STRAW is re-created each year based on findings from evaluations and interviews that include mentors, laboratory heads, students, and teachers. A committee of participants that includes science writers, the evaluator, and me, designs STRAW to help novices maximize their research experiences. Action plans adapt STRAW for classrooms. Peer workshops adapt STRAW for teachers locally and nationally. Scientists who teach in STRAW learn how to work with K-12 teachers and adolescents and become mentors, Scientists-in-the-Schools, and potential teachers in the Teaching Laboratory. Dissemination also occurs at national and international meetings and over the Outreach website http://www.rockefeller.edu/outreach

Early evaluations confirmed that the Program was having a positive effect on the teachers and their students (6,7,14,15). Future evaluations will include present and former teachers in order to gauge their use and success with STRAW. The evaluator will work with mentors as well as teachers to stimulate increased classroom use of STRAW materials and methods. Her work with the teachers will further their professional development by teaching them methods to recognize and implement inquiry-based learning and help them evaluate the extent to which it is occurring in them and in their students (16).

Excelling in science fair competitions may be a motivating factor or an outcome of the mentoring process. However, learning the content of science by using the methods of inquiry is the main goal of Science Outreach. Investing in a clear view of the Program's first decade is timely, essential for continuing to improve the mentoring process, and most important for charting the decades ahead.

References

[1] S. S. Hall, The Smart Set, *The New York Times Magazine*, (June 4, 2000) 52-57 ff.

[2] J. B. Donovan, To Think Like a Scientist, *Howard Hughes Medical Institute Bulletin*, 14 (2001) 32-33.

[3] J. B. Donovan, Mentoring the Youngest Researchers, *Howard Hughes Medical Institute Bulletin*, 13 (2000) 16-19.

[4] J. B. Donovan, Growing Up with HHMI, *Howard Hughes Medical Institute Bulletin*, 13 (2000) 8.

[5] H. J. Walberg, Improving School Science in Advanced and Developing Countries, *Review of Educational Research* 61 (1991) 25-69.

[6] B. Kaiser, Teachers, Research, and Reform: Improving Teaching and Learning in High School Science Courses. ERIC Document ED400191. Presented at the National Science Teachers Association Global Summit, 1996.

[7] B. Kaiser, *et al.*, Rockefeller University's Success with High School Girls and Their Teachers, *American Association of University Women Proceedings* (1997) 96-101.

[8] R. A. Day, How to Write and Publish a Scientific Paper. 5th ed., Oryx Press, Phoenix, 1998.

[9] National Research Council. The National Science Education Standards. National Academy Press, Washington, D.C., 1996.

[10] J. Mervis, How to Produce Better Math and Science Teachers, *Science*, 289 (2000) 1454-1455.

[11] H. Etzkowitz and J. Alonzo, The Extensible Research Group: High School Students and Teachers in the Laboratory; A Co-existive Evaluation of the Outreach Program at Rockefeller University, personal communication, 1995.

[12] H. Etzkowitz and J. Alonzo, Creating a Network: The Science Outreach Program Faculty-Teacher Meetings at Rockefeller University, personal communication, 1996.

[13] H. Etzkowitz and J. Alonzo, More Than a Lab: The Rockefeller University Teaching Laboratory, personal communication, 1998.

[14] S. Chu, Conversations with Outreach Teachers: 1992-1993, personal communication, 1993.

[15] S. Chu, Evaluation of the Science Outreach Program: 1994-1995, personal communication, 1995.

[16] C. Rubin, Evaluation Plan for the Outreach Program, personal communication, 2001.

The Role of History in Training
Canalisation of High School Students to Scientific Research

Ayse Gulcin KUCUKKAYA
University of Trakya, Faculty of Eng. & Architecture,
Dept. of Restoration, Edirne, Turkey

Abstract. Although scientific research on conservation issues has been a large-scale competition in developed countries, irreplaceable cultural heritage needs protection and conservation particularly in developing countries. Awareness of high school students on the importance of the scientific studies for the conservation of monuments that can be used also to build support for the protection of these fragile resources will be probably a very effective tool to canalise them to science education. Significant experiences in raising awareness of young people to the fragility and safeguard of cultural heritage will be investigated in this paper. It is supported by the experiences in Europe and fundamental principles set for the creation of effective programmes for children to canalise them in to scientific education.

1. Introduction

Scientific research provides a unique and unparalleled opportunity for outstanding achievements in young ages. Moreover, research training makes the social circles surrounding the students (schoolmates, family, relatives, etc.) understand science and breaks the alienation from scientific research in a significant part of the society. Science education begins at the nursery and ends by the completion of a Ph.D. study. The past is everywhere. Our heritage conveys a message to be protected and to be heard everywhere. Historic buildings are accessible to everyone.. They can be found all over European cities, villages and the countryside and vary from palaces to privies and from terraces to tombs. Awareness of high school students on the importance of the scientific studies for the conservation of these monuments will be probably most effective tool to canalise them into science education.

2. Experiences in Raising the Awareness of Young People to Safeguard Heritage

Many cultural institutions organise activities specifically aimed at young people, enabling them to discover the history and life of objects and heritage in general, but very few of them make a point of the fragility of this wealth and the risk that it will disappear for good if everyone does not adopt appropriate behaviour.

UNESCO's Young People's World Heritage Education Project was launched in 1994 to raise awareness among students and teachers around the globe about World Heritage conservation. The project[7] is co-ordinated by the UNESCO World Heritage Centre and the Associated Schools Project Network (ASPnet) Co-ordination Unit and funded by the Norwegian Agency for Development Co-operation (NORAD) with previous support from the Rhône Poulenc Foundation, in France (1). Through the integration of World Heritage education into secondary school curricula, the project aimed to involve young people in World Heritage conservation and to create a new synergy amongst teachers, curriculum developers, heritage experts and other relevant people from local to global levels (1).

In 1991, ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property) organised a major competition in Rome[8]. Italian school children were invited to design a poster to draw attention to the value of their cultural heritage through the conservation of historic buildings (2). The competition was so successful that in 1993 the idea was extended to the other eleven European capitals. The winning Italian and London entries have been shown at an exhibition at the Academia Italian during summer 1993. The London competition was organised by the Central Bureau for Educational Visits and Exchanges. In December 1993 the London winning entries visited Rome where they will have been shown alongside of the other European capitals. Education Service of English Heritage and Academia Italian organised some competitions to encourage teachers to give a higher profile to the conservation of historic buildings and provide more long term benefit to schools participating in the competition in 1991 and 1993 (2). The Education Department of the Academia Italian is aware of the need to encourage greater visual awareness amongst school children and the potential that exists to use the conservation of historic buildings through most subjects of the national curriculum (2).

The heritage, more often exploited than protected, is deteriorating at an alarming rate. Given this problem, ULB (University' Libre de Bruxelles) in Belgium launched the programme "Raising Public Awareness of the Need to Safeguard the Heritage". Eleven institutions from six different countries were involved. Its purpose is to make the public conscious of the fragility of heritage, of the fact that it cannot be replaced and of the need to ensure its protection (3).

2.1. Some Experiences in Europe on Archaeological Sites

A. To make young people aware of the importance of preserving the national heritage, and teaching them different aspects of conservation and restoration, three education centres for archaeology have been established by the **Israel Antiquities Authority in Jerusalem** (4).

---

[7]The main result of this project has been the production of the educational resource kit for teachers entitled *World Heritage in Young Hands*. The kit, which is the result of national, regional and international consultative meetings with teachers, students and heritage experts, has been tested in 104 countries around the world. Originally published by UNESCO in English and French, the kit now exists in the other four United Nations official languages and more that 20 national language versions. The project also publishes a newsletter and organises international and regional youth conservation workshop for students and teacher-training seminars on World Heritage teaching (1).

[8]ICCROM, "*Youth and the Safeguard of Heritage*", Seminar on Youth and the Preservation of Heritage: European Experience, Rome, and 18-19 February 2000.

They run four different programmes for schools

1. The investigation class: a continuing enrichment programme in the school, led by the instructor who comes to the class once week for a 90 minute session during one semester.
2. "An Archaeological Celebration" one-off workshops and activities conducted in schools around a central theme chosen by school. For example: communication and the development of writing in ancient times ancient people who have left their mark in their country (Egypt, Greece, Rome, etc.).
3. An active tour of a site.
4. In the footsteps of an archaeologist: experiencing the work of an archaeologist. Survey, study excavation at an archaeological site especially designated for teaching purposes and conservation activities.

B. "Ostia Antica" had been participated in a programme of the European Union, which was also developed in Belgium, Denmark, France, the Netherlands and the United Kingdom (5). The project was aimed to raise public awareness of the difficulties encountered in the conservation and restoration of European cultural heritage. Therefore, as part of this project, to show various aspects of the conservation and management of this archaeological site, a specific route around the main sites in Ostia had been determined. The points on the route were marked by the logo "Let's take care of our heritage". The brochure of the route showed how difficult it is to conserve and restore an archaeological site. The titles of the routes were these,

- Ostia Antica conveys an historic message
- Ostia Antica is unique and irreplaceable
- Ostia Antica is full of valuable
- Ostia Antica is vulnerable and fragile
- The preservation of our cultural heritage is of common concern

C. A ten years projects, to increase the awareness of young people of the historical heritage of the **City of Arles**, had been finalised in 1999 (6). Young people received instruction, met archaeologists, curators, restorers, architects and historians all year long, and test the knowledge they have acquired in labs. Teaching young people about heritage in a school environment through the use of living and active didactic methods helps integrate them better, develops their creativity, and encourages them to the science education for the preservation of the cultural heritage.

D. Numerous activities are offered to children and their families in the **Xanten Archaeological Park** that is on the site of vestiges of an ancient Roman villa (7). The on-site reconstruction of buildings enhances public awareness of the short-lived nature and vulnerability of heritage.

2.2. Experiences in the Museums

Raising awareness of young people, and the public, of the necessity to preserve particular objects from deterioration, and of the role played by museums in the modern societies have been developed by the participation of school and teachers, education officers, museum technicians, local authorities. The museum provides a different and stimulating learning environment for all kinds of subjects, one of which is science.

A. The messages about how we preserve items in a museum are translated into helping young people look after their own possessions properly in **Falkirk Museum in UK**. By focusing on the materials from which items are made, the exhibition encourages visitors to look more closely at how items are made. This helps to reinforce the message that museums are relevant to modern world (8).

B. The **Musee de la Musique in Paris** offers a great many possibilities for the public, especially children, to become familiar with the instruments: a sound itinerary, performances by musicians in the museum itself, or concert in the amphitheatre. Even before introducing the notion of fragility of the works, the educational service tries to make them familiar with the idea of music and its role. Workshop tours make it possible for them aware of the materials and their delicate nature. Those at the Musee de la Musique note those children's behaviour changes: they are more attentive during their visits; they have a better understanding of the need to protect and conserve (9).

C. Raising of awareness by young people of the fragility, restoration and conservation of the local cultural heritage meets with greater and greater success every year in Italy. The **Luxoro museum**, whose collection of crèche' figures is put on display every year, is a good example. Young people discover the historical and technical features of these figures, meet specialists dealing with the collection and work in laboratories set up in their schools (10).

D. By increasing awareness on the part of young people of the notion of heritage in common and hence universal property, or the complexity and fragility of the material the works are made of, the education service of the **Muse'es Royaux d'Art et d'Histoire in Belgium** involved children in their protection (11).

2.3. The Aims of These Studies

- To raise awareness of the public, and young people in particular, of heritage conservation, through exhibitions and displays, studios visits, live video links and hand-on activities.
- To raise cultural awareness among these teenagers and convince them of the necessity of saving their cultural heritage through appropriate methods of preventive conservation.
- To promote co-operation between existing scientific research training projects on conservation by raising the possibility of more intensive student-exchanges.
- To support the existing projects by exchanging their experiences and outlining successful organisational and fundraising tactics.
- To be the model to the initiation of scientific research training projects in countries where it does not exist.
- Finally the most important aim is to canalise students into scientific research on conservation issues using history.

3. Science Education on Conservation in Turkey

Turkey has signed the World Heritage Convention in 1983 and through the work carried out under the responsibility of the General Directorate for the Preservation of Cultural and Natural Heritage has so far registered 9 locations on the World heritage List (12). Awareness of high school students on the importance of the scientific studies for the conservation of these monuments and raising awareness of young people to the fragility and safeguard of cultural heritage would be most effective and necessary tool to canalise them into science education in Turkey.

4. Conclusion

The cultural heritage is fragile, it is unique and cannot be replaced, and we have duty of guaranteeing access thereto for present and future generations. Historic instruments such as history, archaeological areas, historic gardens and buildings or museum materials may be used as a tool to canalise high school students in to scientific research and education. The safeguarding of the heritage, both intangible and tangible property requires scientific research carried out by professionals. Making young people aware today means instilling in tomorrow's adults a sense of responsibility towards their cultural heritage.

With these respects;

- An archaeological area can be used as a camping place.
- A partaking workshop activity may be focused on conservation in an historic environment.
- An historic building will be used as a case study object, for the determination of the cause of deformations or deterioration which require scientific studies.
- An competition activities on an painting, poem or novel activities can be determined on an historic site, monument, national park or local museum.
- And finally, very often, historic environment should have been used as the tittle of the competitions on drawing, painting, designing or poetry of high school students.

5. Acknowledgements

Many thanks to the staffs of ICCROM for their help to send me the right documents and address of contact persons on the studies of the raising awareness of young people on conservation issues to canalise them in to scientific studies in Europe.

References

[1] UNESCO, ASPnet Co-ordination, *www.unesco.org,* Paris, 2002.
[2] Unit, Education Service of English Heritage, "The Conservation of Historic Buildings", *Your Past Our Future*, Booklet, London, 1993, pp. 1-16.
[3] C. Perier-D'ieteren, "Universite' Libre de Bruxelles", *Youth and the Safeguard of Heritage*, ICCROM, Rome, 2000, pp. 163-170.
[4] N. Amit, "Israel Antiquities Authority, Jerusalem-Israel", *Youth and the Safeguard of Heritage*, ICCROM, Rome, 2000, pp. 29-33.
[5] M. Bedello, "Site Archeologique D2 Ostia Antica, Rome-Italie", *Youth and the Safeguard of Heritage*,

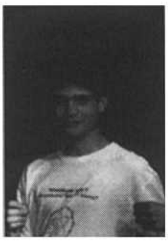
ICCROM, Rome, 2000, pp. 49-52.
[6] O. Caylux, "Musees de la Ville D'Arles, Arles-France", *Youth and the Safeguard of Heritage*, ICCROM, Rome, 2000, pp. 35-39.
[7] M. Hilke, "Parc Archeologique, Xanten-Allemagne", *Youth and the Safeguard of Heritage*, ICCROM, Rome, 2000, pp. 41-47.
[8] C. Whittaker, "Falkırk Museums, Falkırk-UK", *Youth and the Safeguard of Heritage*, ICCROM, Rome, 2000, pp. 55-60.
[9] D. Meyran, "Muse'e du Musique", *Youth and the Safeguard of Heritage*, ICCROM, Rome, 2000, pp. 61-64.
[10] S. Maione, "Muse'e Luxoro, Genes-Italie", *Youth and the Safeguard of Heritage*, ICCROM, Rome, 2000, pp. 73-77.
[11] F. Putman, "Muse'es Royaux D'art et D'histoire", *Youth and the Safeguard of Heritage*, ICCROM, Rome, 2000, pp. 93-96.
[12] www.kultur.gov.tr

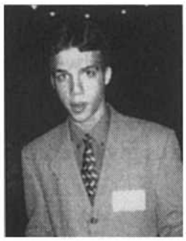
Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Six Years of Scientific Research Training in Hungary

Progress, Plans, Problems

Péter CSERMELY, Zoltán BORSODI, Tamás KORCSMÁROS, Bálint PATÓ
Hungarian Student Research Foundation
H-1149 Budapest, Dongó str. 8, Hungary





Abstract. The first six years of a new program to organize high-level scientific research training for gifted high school students in Hungary are described. Besides giving top-level research opportunities for talented students in their most receptive age, the program already helped the establishment of almost two hundred scientific research clubs in high schools of Hungary, Romania, Slovakia and Serbia, providing a focal point for science training of high school teachers and helping regional cooperation in Central-Eastern Europe.

1. Introduction

Six years ago a new program has been established in Hungary helping gifted high school students (in the age between 14 and 20) to find mentors who introduce them to scientific research in Hungarian universities or research institutes. The program gained an overwhelmingly positive response from the Hungarian scientific community. Mentors are of highest scientific merit: among them 78 are members of the Hungarian Academy of Sciences (*George Olah* is a Nobel Laureate), and most are respected professors of their research field. The patrons of the program are *Ferenc Mádl*, the President of Hungary and *József Pálinkás*, Minister of Education (both are well-known scientists themselves, members of the Hungarian Academy of Sciences).

Whenever this program was introduced to new areas, first we always had questions: are not these guys simply too young for this? Science is something "serious". Are not you making fun of it? We believe that high school students are in an excellent age to start scientific research. Excellent, because this age is the first period in life, when someone wants to explore himself and the surrounding nature with the systematic, logical way of understanding, science uses. Excellent, because science is an area of exploration, which is – by nature – infinite. Excellent, because science can be perceived only as an international endeavor. And finally excellent, because good science does not know hierarchy. Bright high school students are equal with the Nobel Laureate whenever, they have a new question rising from a fresh mind. Science can break the petrified borders of society, and give a chance for self-expression at a different scale. This unusually wide channel of "status-jump" is especially important in many of the Central-Eastern European countries, where more than ten years after the regime-change social differences broadened, and social mobility was rather diminished. In these countries talent support became an even more central issue now than it was in the past.

Why does a student start scientific research? A general answer is not easily found: many students realize their talent, their need to change their life and find a way for self-development, independence, and social endeavor in form of scientific research. However, the most important motivation is always a part of the "personal history": without a devoted teacher, a deep-thinking relative, or someone else in the close neighborhood students seldom have or trust the examples around them. Therefore instead of a – probably false – rank-list of motivations let us give a concrete example from our recent questionnaire[9]:

> "When I was starting to explore my family traits, I was shocked to find that many members of my family were participating in important events of recent history. History became personal, and I began to like it. Now I pursue studies of local history." (Lívia Kovács, born 1984)

2. How do we work?

We provide a link between high school students, who wish to participate in research and devoted scientists who are willing to teach them without any payment or other direct benefit. Many times this collaboration results in scientific research papers in various journals. Much more importantly, the research experience leaves a mark in the student, who will keep this throughout the whole life. János Balogh, a respected Hungarian scientist told once: "You guys teach not only science here, but give moral standards, life itself." Indeed, many students find a second home in the laboratory, team they work. Their habits, aims, perspectives, whole life has changed.

At first we were rather frightened. We have a few hundred mentors and more than 100,000 students in high school. How are we going to select them? Realizing that scientific merit may come from a thousand sources, we instantly discarded any types of test, being it any IQ-test or questionnaire of the respective field. "Science is one of the most frustrating

[9]The questionnaire was distributed to all current and former high school students in late 2001. We received back 96 questionnaire from current, and 45 from past student researchers. If not otherwise stated all data in the current summary are coming from the evaluation of these answers.

professions." (Csaba Pléh, a member of the Hungarian Academy of Science in the field of cognitive psychology). The only general advice for success is motivation and endurance. Science also needs a lot of independence. How can we test these? During the years we found two screens, which may sound simple, but work remarkably well. The essence of the formula sounds rather lazy and selfish: we give no help.

53 % of participating students find us *via* their teachers, 15 % are persuaded by their student fellows already knowing the initiative, 12 % read or hear about us from the media, and 5 % accidentally finds our home-page during web-surfing. There is only one potential source we intentionally disqualified: parents. Each kid is a genius for the father or mother. However, if the motivation is not internal, but comes mostly from family-pressure, the cooperation between the student and the teacher will not be long-lasting, joyful and creative.

When a student finds us, he has to answer to two simple questions:

1. Why do you want to pursue research?
2. Why do you feel yourself better than average?

These seem to be rather simple questions. However, our experience shows that to find an answer to them in this age is by itself a rather good screen for maturity and motivation. To be honest, we accept almost all answers. (Please do not tell this in the Hungarian schools...☺) We would like to give the chance to almost all students to pass the second screen.

The second screen is also very practical, simple and a good "mimic" (actually a part) of real life. The student has to find the mentor alone. All the courage has to be collected before that first letter, email, or phone call to address a professor, or – for God's sake – a Nobel Laureate. All our researchers are waiting for these letters and calls. Students know this. Still. That very first step makes a good second screen.

This initial "cruelty" is not a general philosophy. We do not leave our students in the desert. If the student does not get an answer from the mentor, he finds a mentor who is not helpful enough, or he does not find a mentor of his interest at all: he is fully entitled to our help. Mentors are called sorted, listed, re-listed and enlisted all the time.

3. Mentors and students

In 1996 we started with approximately 300 mentors. The number of scientists devoted to the program doubled in the last six years. So far six editions of the list of mentors were published in 4000 copies each, and have been sent to each Hungarian high school, to 500 high school teachers who regularly recruit new students and to almost 1000 gifted students personally. Winners of various student competitions, student members of MENSA HungarIQa, or student authors of scientific papers in the Hungarian Journal "World of Nature" were all personally addressed each year.

At start we had a hundred students only (1). Currently we have 800 and an additional 3200 working in student research clubs. The ratio of boys and girls was always close to fifty-fifty (currently we have 55 % boys). This shows that the interest for science is independent of gender at this age. Therefore the rather significant "male-dominance" of science is mostly derived from conflicts between the "publish or perish" principle and child-birth, which often results in a several-year gap for women in science.

Four years ago[10] 50 % of students worked in life science laboratories, 30 % attended to Faculties of Arts, 19 % to Faculties of Natural Sciences (life sciences excluded) and there was 1 % in economy and law. Currently the ratio of life science and economy/law researchers are unchanged, however, natural sciences and arts drew 27 % and 16 %, respectively. The life-science dominance (which has a very significant share of environment protection) shows the student's continuing interest for the living nature around them. On the other hand, the highly competitive crowd for the entrance exams to faculties of economy and law seems not to be driven primarily for scientific interest...

Our students reached an average mark, which is 90 % of the best. Their 84 % participated in one or another scientific competition besides their research. 97 % planned to go to universities and after a very strict entrance exam 93 % of them was actually accepted. Many of our students started their university studies abroad in Europe, in the USA or in Japan.

If we examine all the 800 currently listed students 25 % of them were from the capital of Hungary, Budapest; 32 % from Hungarian towns with a population larger than 100,000; 25 % from smaller towns of Hungary and 21 % from villages. Students from Romania, Slovakia and Serbia are 23 % of all[11]. Three years before 28 % of our students came from Budapest, 18 % from big, 31 % from small towns and 23 % from villages. Data show that students from Budapest (an oversized capital of Hungary having more than 20 % of total population and an even much greater share of scientific and cultural life) are not dominating the initiative. The most important part is the unchanged quarter of students coming from small villages. These are the researchers who probably would have never found a similar possibility without our help. Not surprisingly, many of our students are coming from families of low income. We set up a special "quick-aid-fund" to cover their expenses for travel, books or other small items. Even more importantly, ***all of our programs are free of charge*** to give an equal chance to participate.

4. Organizations

In 1998 a Research Student Foundation was established to channel the financial help for the program. The annual budget of the Foundation grew to approximately 100,000 euros by 2002. Sponsors of the action include: the Béres Foundation, EGIS Ltd., Gedeon Richter Ltd., Hungarian Patent Office, Ministry of Education, Ministry of Environmental Protection, "Műszaki" Publishers Budapest, NATO, Program for Children and Youth and UNESCO.

---

[10]Our former questionnaire was from 1998 having a sample of 76 students.

[11]If we restrict this statistics to the questionnaires we recently received, 20 % of the students are coming from Budapest and 24 % are from Romania, Slovakia and Serbia. The remarkable similarity between the ratios of the two data sets suggests that the sample we had with the "responders" to our questionnaire may be a rather good representation of the total population.

In 1999 participating students, mentors, high school teachers and scientific research clubs formed a Research Student Association, which currently has approximately 500 members. The issues of the movement (including all finances) are decided by the student president (currently Mr. Bálint Pató) and by the two deputy presidents (currently Mr. Zoltán Borsodi and Tamás Korcsmáros). The president and the deputies are elected each year by the participants of the National Conference. Students are eligible to be a member between age 14 and 20. After passing the age limit, or grade I. at a university they continue their research in the undergraduate research student associations and can apply for being a "student-mentor" of the movement.

5. Annual Conference – Summer camp

From 1997 six national student conferences were organized. In each of these conferences 40 to 80 students participated, and 20 to 30 scientific presentations were made. From the second conference these meetings were organized as a summer camp in July near the Lake Balaton (1). Besides the short presentations of students on their own research, successful scientists talked about their approach of science and about their devotion. Psychologists and social-psychologists discussed the possible dangers of being outstanding in a field, and showed how to solve the conflicts, which might arise from this situation. The camps were all free for the participants. The major language of the camp is Hungarian. However, almost all participants speak a rather good English, and in case of a significant participation from abroad, we will organize an English program as well. As the size of the movement grew, more than twice as many students wanted to come than the size of the camp: the selection of "campers" became increasingly difficult. We did not want to make "clones" of the camp, since the invitation of top-level scientists would not be possible to all of them. Therefore, from 2001 only the winners of the national conference of high school science clubs can participate in the research camp.

6. Science clubs in Hungarian high schools

The Research Student Foundation announced a competition for 2500 USD in the fall of 1999 to help the establishment of science clubs in Hungarian high schools (2). Since then the call for application was repeated each year offering a steadily increasing financial support. Members of these clubs may be involved in a research project requiring a team-work, or may perform individual studies and inform each other regularly about their progress. Most of the research clubs also invite established scientists to speak about their own experiences in research, or to summarize recent advances in their field. The Foundation receives approximately a hundred applications each year from Hungary, Romania and Slovakia. In these science clubs more than 3000 students are being introduced to scientific research.

From 2000 a special annual meeting of these research clubs has been organized. In these meetings almost 200 students gave an account on their research. From 2002 our movement grew to the point where a single annual meeting would be too large to accommodate. Therefore we organize regional student conferences (this year we had four: in Budapest, Győr, Szeged and in Romania) and the winners of these conferences can participate on the annual meeting on the national (actually: multi-national) level.

From the beginning we had an ongoing discussion around the question: to what extent should we exploit the natural drive of this age for competition? True science is not a race. Science is joy, hard work, exploration, meditation, and the unprecedented feeling of the birth of a novel thought. True science is a touch of God. Still. High school students have such a great tendency to compete that we simply could not leave this element out of our movement. We do have prizes. However, our prizes are not oversized. Therefore – despite of their merit – we avoided to grant a free entrance to the universities even to our best students. We want students who join us not because of any prize, but because of the joy of science itself. Besides this the most what we can offer to our students are themselves. To many of them our conferences and camps give the first opportunity in their life to find not only nice chaps, pals but true friends.

7. Organization of high school teachers

During the last six years we established a network of 500 high school teachers who regularly recruit students to work in research laboratories and/or lead science clubs in their own school. In 1999 the first national conference of these teachers was organized. The successful event was a forum to exchange various methods on the establishment of science clubs, local competitions, fundraising, recognizing talented students, etc. The conference also made a possibility for a discussion with government officials on several general issues, such as governmental help to enhance research activities in high schools, and to increase the number of Ph.D. studies among high school teachers. Recently, due to the increasing financial support an expansion of this programme became possible by opening an office of the movement. We plan to offer scholarships/awards for the best teachers in scientific research training, organize student/teacher research pairs, form virtual teams by the help of the Internet, explore international collaborative teacher/student research by Internet connections, help the development of novel Science Education curricula (e.g. that of molecular biology, genomics, nanotechnology, etc.), develop a special web-site offering extra materials for current topics in science education, promote the formation of the Hungarian Association of Science Educators, etc.

8. Contacts

8.1. Most Important Hungarian Contacts

In the last six years we have established a good contact with almost all official members, bodies of the scientific life in Hungary as well as related government institutions and NGO-s. Among this long-long list we would like to mention only the two most important points, the "input" and the "output". Our initiative can help gifted children between the age of 14 and 20. Seldom we have an exceptionally independent and capable student in the age of 12, or 13, who is able to participate in scientific research in some special fields. Usually these children are recommended to us by the Hungarian Talent Support Association, where the vice-president, *Dr. Maria Herskovits* is a long-time supporter and friend of our initiative. *Vice versa*, if we are approached by a talented student (or – usually – by the parents), who is below our usual age limit, we direct the student to Dr. Herskovits. A research student, who becomes "too old" for our movement, enters the Hungarian Association of Research Undergraduates, which is the same movement at the university level having more than 30000 members and enjoying rich traditions of its fifty years of existence.

8.2. International Contacts

The program has several hundred Hungarian speaking students, high school teachers and science clubs from the neighboring countries of Romania, Slovakia and Serbia. Our primary goal in the international scene is to enhance the regional cooperation in this segment of Central-Eastern Europe. Our goal is to form an international network for student/teacher exchange as well as to exchange and propagating existing "know how"-s of scientific research training. We have mentors from Australia, Austria, Canada, Italy, Romania, Slovakia, Serbia and the USA.

As another type of activity, the program already established several contacts with other organizations helping gifted children abroad. The sponsorship of the Deutsche Schülerakademie, Bildung und Begabung made possible to one of our members the participation in their summer camp from 1998, two of our students are invited to the SciTech camp in the Weizman Institute in Israel from 1999. We sent two students to Dublin, to the camps of the Irish Center for Talented Youth, and will send our first student to the National Institutes of Health (NIH, Bethesda, USA) for a two-month research practice in 2002. We also accepted a Belgian and an American student in our summer camps. It is our goal to extend these contacts in the future possibly in the form of mutual exchanges of talented young students.

As a recent development, our best student was invited to the Nobel Ceremonies each year in Stockholm. The selection of the student will be arranged by a special competition together with the Hungarian Association for Innovation (http://www.innovacio.hu).

Finally let us close with three quotations from our recent students:

> "I became to know many interesting people: I became to know the world better. I have already received a great help to develop my endurance from your organization. The lists of the mentors gave me a chance to crystallize my widespread interest, and to focus to that what I need most." (Brigitta Sipőcz, born 1984)
>
> "It is always a fantastic feeling to ask nature! – Especially when one does receive an answer." (Tamás Visnovitz, born 1983)
>
> "It is a great fortune for a student to have an opportunity like this. Therefore Your work is highly important, noble, and honorable." (Tünde Gál-Berey, born 1982)

References:

[1] P. Csermely. Scientific research training for gifted children in Hungary. The Biochemist 21 (June 1999) 28-30. (more information can be found on the web site http://kutdiak.hu)

[2] Csermely, P., Halász, G., Jenei, G., Máthé, J., Mikló, L., Solymári, D., Szekeres, Á., and Tamás, G. (2000) Research training between 14 and 18 in Hungary. Biochem. Education, 28, 132-133 The ratio of boys and girls was always close to fifty-fifty (currently we have 55 % boys).

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Visnjan Educational Project: Introduction to Science through Astronomy

Korado KORLEVIC
Visnjan Observatory,
Istarska 5, HR-52463 Višnjan, Croatia

Abstract: The Visnjan Educational Project - VEP started as one of the non government answers to the rapidly evolving educational and social environment during the last days of the socialist era in the former Yugoslavia. The idea has survived and grown through the periods of extreme hardship: the fall of communism, disintegration of one country and formation of national states, the war destruction, the post war lust and corruption environment. The VEP embrace 14 -18 years old high school pupils and it is carried out by volunteers. The main idea was to demonstrate in practice to young population the existence of another system of values and that the career in science and technology can be a prized goal. During the 14 years of using astronomy as an introduction to science, the used methods have been changed and astronomy become a "shiny" part of multidisciplinary activities that spread from robotics to biology. The response of the high school pupils has been enthusiastic, and anonymous questionnaires show us that the VEP was for the majority of them the "life changing experience". As byproduct of these educational activities, a new telescope was build and more than 1400 new minor planets were discovered and followed up. This work on minor planets made the Visnjan Observatory the most prolific observatory of small bodies on the European continent in the 20th century.

1. The social, political and historic environment

Since the educational work has a great influence on the youth, during the totalitarian regime in the former Yugoslavia, the communist party (SKJ) organized, financed, and led the complete line of the school system. Also through subsidiaries as "Savez pionira, Savez omladine, Narodna tehnika, Savez sportova" and some smaller branches of the same but different names (1), developed a near complete control of the extra scholastic activities. In the first years after coming to power, communists strongly supported these activities with the goal to destroy the remnants of similar religious organizations. In order to have the control during the summer non-school period, entire campus-like complexes were built. When the influence of religious organizations weakened and the first results of the soviet style planned economy started bringing wealth, the importance of these organizations for the communist party decreased (2) to the point where leading positions became a "parking" place for incompetent political hierarchy members (3).

The problems started after the initial positive effects of the planned economy. The ratio of number of patents per inhabitant was catastrophic. It was less than 1/8 in comparison to Bulgaria on the East and 1/27 to Austria on the West. Similar comparison to Germany or Switzerland was smaller by two orders of magnitude (4).

In the 70's, the communist party made the school system, industry and youth's organizations more "creative" by declaration. A very complex, sport like, system of competitions for pupils in science and technology, called PZM, was developed and supported through the school system and Narodna tehnika (5). The response of the pupils and teachers was enthusiastic in the beginning, but after years without new challenges and changes and missing incentives for teachers the enthusiasm faded (6). Also at that time, it became evident to pupils that possibilities for a career in science/technology were dim. The PZM system continued to live in schools and cities where the political structure was more open to changes (6). During the last years of the communist government, the "nice facade" of the system started to fall and the economic hardship become evident. The scientific and educational communities were hardly hit by years of neglect: prohibitions to import literature and equipment, and travel to conferences. One of the ways embraced by the communist party to exit the recession was the Karl Marx's theory that the science is one of the master producing forces (7). Many conferences on that topic were organized by the government institutions. The enhanced education for gifted pupils became one of the leading ideas and the educational activities with the gifted and talented pupils became a political trend. In this positive social environment, a few non-governmental organizations emerged and grew. They were led by education enthusiasts and youth. The two leading such initiatives at that time were SC Petnica (8) and MAN Leonardo (9).

2. Visnjan Educational Project - The history

In the year 1976, the Visnjan elementary school and the local Visnjan Amateur Astronomical Society started extracurricular education of gifted pupils through science and technology projects. For more then a decade, Visnjan was one of the best Sci/Tech education centers in the Former Yugoslavia based on results on national competitions, but the choice of pupils was limited to those from Istra peninsula (Istarska Zupanija).

After the supporting push from the SC Petnica and MAN Leonardo, supported by local political leadership, the existing educational activities with gifted pupils at Visnjan expanded. By mutual agreement between the Local political organizations, the Visnjan elementary school and the astronomical society, the dormitory was build to accommodate non-resident pupils. In 1989, the first workshop was organized under the name "The Yugoslav Summer School of Astronomy". 21 high school pupils and 10 team leaders and lecturers attended. The main scientific result was the meteor observations that were published the same year in the journal of the IMO - WGN. In addition, a poster was presented at the Conference of the International Meteor Organization (10). The scientific.

educational, and management experiences, mixed with the changing environment of the disintegration of communist parties, were used to model the shape of the next workshop. The astronomical projects became multidisciplinary projects linked with other scientific and technological fields. All the work was published and the official language became English so that accepting pupils and lecturers from abroad was possible. The same was with the other activities where the political leadership never understood the far reach of the ongoing initiatives.

But politics started to mess with the lives of people as the communist parties in the federative state disagree on the common politics and the economics. Political disagreements grew until the disintegration of Yugoslavia to semi-independent states in 1991. The federal army led by orthodox communists strongly influenced from Belgrade tried to prevent the separation of the Yugoslav Republics, through open aggression, occupation, and blood lust - war. The workshop changed name to "Visnjan School of Astronomy" and the participants had to struggle in 1991 to return home because the war started during the workshop.

This was an extremely difficult period of time for pupils and team leaders, some of them becoming refugees. The whole balance of civil society was gone. The same or even worse for the society was the post war period.

The stratification of the Croatian society continued, the women place in the society continued to degrade, and all that was reflected in the girls participation on the workshops, as visible in Figure 1. – see on next page).

Trying to run educational programs during the war drew Astronomical Society near the bankruptcy. During that time, both telescopes were lost. They were used as military spotting scopes for the cities of Gospic (Croatia) and Sarajevo (Bosnia).

Instead of closing the observatory, the educational activity increased trying to give an alternative to the continuous exchange of war bulletins in the media. Things also changed qualitatively. Following the experiences from the world (11), the Amateur Society changed to Public Observatory with the goal to become an excellence project in education (12). The war years, from 1992 till 1995, were extremely difficult years for any kind of activities. Drago Sirovica, the meteor group team leader died during a war action. The government did not support activities that where without the full control of the state. That included many non-governmental associations or projects. The VEP survived just by the work of many volunteers, and support by the local authorities and some international foundations, such as the "Beringer Crater Company Foundation", the "Open Society Foundation", the "World Laboratory Foundation" (13) and many private donations.

The lost telescopes were replaced by a telescope build as result of many student projects (14)(15) and new program of observation started (16). As the ties with similar projects in the former Yugoslavia became difficult (Petnica), or the observatories were destroyed (Sarajevo), or projects ceased to exist (MAN Leonardo), the preferential direction for contacts and exchange of experiences moved to observatories and institutions from Austria, Belgium, Germany, Italy and the USA. After the war, a complex and very difficult period followed for the Visnjan Observatory to survive. Hopefully, in the last few years the situation is becoming better as the Croatian Government Office for Cooperation with NGOs starts to support one part of the educational activities (17). After the situation in the region started to normalize, the old telescope optic had returned from the city of Sarajevo and in the year 2001 we had the first exchange of visits with the SC Petnica.

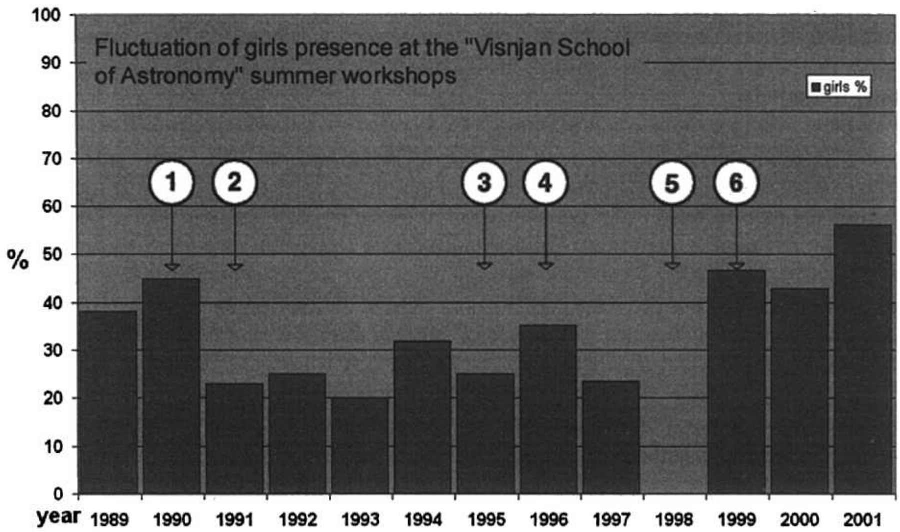


Figure 1. The fluctuation of presence of girls at the summer workshops "Visnjan School of Astronomy" strongly reflects political and social environment in Croatia in the period of 1989-1998. After 1998, a kind of "affirmative action" was taken and special care was given encouraging the feminine pupils to attend. The result is optimistic now as far as VEP is concerned, but the general situation is changing slowly. The points indicated by numbers represent: 1.) The fall of the communists parties and the beginning of political pluralism. Also, the growth of the economic wealth in the former Yugoslavia. 2.) Start of the political radicalization, Yugoslav army's aggression on the main cities, the war starts. 3.) The war ends by military means. 4.) The war "really" ends by a political agreement. The Yugoslav army withdraws from Croatia. 5.) The economic and moral disintegration of the society start and the women part in the society becomes "the breeding part of the society". 6.) After the year with no girls, with the support from the World Laboratory, a number of actions were taken to reach and encourage the high school female pupils to participate. After 2001, it seems that this support for feminine population will be less necessary.

The multidisciplinary concept of workshops held at the Visnjan Observatory was used to start two similar projects in Italy, one at the Remanzacco Observatory (18) and another in the city of Ravena as the project of the Bologna University (19).

The new technology telescope developed and build in Visnjan from 1993 to 1995 showed great potentials. After supported by new methods and software (20) in the following years, it permitted an important row of astrometric measurements (21) and small body discoveries that placed the Visnjan Observatory on the first place in the number of asteroid discoveries on the European continent in the 20th century.

3. VEP - The Visnjan Educational Project

After the decision that the war situation should not end the educational activities, the idea of a Public Observatory started to emerge through the analysis of feasibility (12), (22). By surprise, the projects were not accepted to receive support by the Ministry of education, so the projects started independently. The observatory became a public non-profitable and non-government organization. The activities diversified in the attempt to reach the largest possible circle of pupils who knew that such educational activities exist. For that purpose the presence of the Visnjan Observatory in the media increased.

Practically, today VEP can be viewed as a symbiosis of smaller projects targeting different population of pupils with the same educational goal: to be the best possible introduction to science and technology to the widest possible population of interested pupils. The subprojects are:

3.1. "Astronomske prirodoslovne noci – A night at the Observatory"

This program was shaped for kindergarten kids and grandparents with their grandsons who want to visit the Observatory. The main purpose was to push the child's imagination and motivate those that have interest and predisposition to take a career in science and technology. Also to disseminate the information that the programs held in the Visnjan Observatory can be one of the ways to do that.

3.2. The Teachers Workshop

Trying to reach the widest possible population of pupils (22), the "Teachers Workshop" was held with the support of the CAS - Croatian Astronomical Society (23). The workshop was a success in its educational part, but the financial results were grim. The next teachers activities in the Visnjan Observatory shifted to less expensive and unfortunately less effective ways of cooperation with teachers: meetings, newsletter, didactic support, slides sets for teaching. The "teachers workshop" continued in Croatia, but in different form and held by the CAS.

The results of the teachers "full immersion" workshop where extremely positive. When the financial situation permit, the "Teacher Workshop at Visnjan" will start again. In the meantime, the communication with the community of teachers would be enhanced by the new technologies.

3.3. Svemir u ucionici – Universe in the Classrom

ISSN 1330-7045. One of the ways to give teachers full information about the main celestial issues, and to substitute the banal ones from the media, was the newsletter "Svemir u ucionici", the Croatian translation of the Astronomical Society of the Pacific's teachers newsletter "Universe in the Classroom". A free of charge distribution of the printed newsletter to schools was not supported by the Ministry of Education because it was published by a non-government organization. The newsletter switched to the web (24) when the technology became available in 1996, but in those days only few teachers had the possibility to reach it. Today the situation is very different and the web form of the "Svemir u ucionici" newsletter is becoming different and illustrated more than even the original ASP newsletter. It is read in a wider area then just Croatia. The translation of the Croatian version is used in Macedonia by the "Astronomical Society of Skopje" for their public presentations (25).

3.4. Nebeske krijesnice - Celestial fireflies

ISSN 1330-4410. One of the main problems that were affecting the results of the high school workshop VSA was the lack of communications and exchange of information and data between the participants. Publishing of a simple newsletter started to fill that gap. The name "Nebeske krijesnice" means "Celestial fireflies", a Croatian name for meteors. The meteor astronomy was widely publicized, as the observers can observe from home, and no equipment is needed. The newsletter shifted to the web form when the majority of pupils were able to reach it. Recently, a few email lists are covering these needs and the printed version has not published in five years. However, to cover some special needs of communications, a reactivation of the printed versions is considered again.

3.5. Acta astronomica visnianiensis

ISSN 1330-2620. Publishing results in the proper scientific format and style is a way in which science works. We tried to give to the pupils a place to do that under the referee from the team leaders and visiting scientists. The printed version started, but it was too expensive to maintain, and everything was shifted to other journals, such as WGN, the Journal of the International Meteor Organization, or as a part of the "VSA Reports", or in the electronic form. The publication of the "Acta" will continue soon as proceedings of various conferences and meetings.

3.6. Visnjan School of Astronomy

The VSA is a summer workshop of astronomy and related sciences. It is held usually in the first half of August and lasts in average for ten days. The official languages are English and Croatian, depends on the group's structure. All the main lectures and presentations are in English. During years, scientific methods and astronomical fields of interest have changed, but not the educational goals - to find the best possible way to introduce pupils to science and the scientific method (26) and find the measure of interactivity between science and technology. These workshops represent a continuing experiment in an attempt to merge science and education, without the usual stress, where the pupils are treated like research colleagues in scientific and technology projects. As the main field of work is done by night, the timetable is also unusual: getting up around 12:30 p.m. Lunch followed by the data reduction from previous night's observation. The lecture in English language starts at 5 p.m. and lasts for an hour or two. Dinner is at 7 p.m. The preparations for observations start around 8:30 p.m. and they run from 9 p.m. till 5:30 a.m.

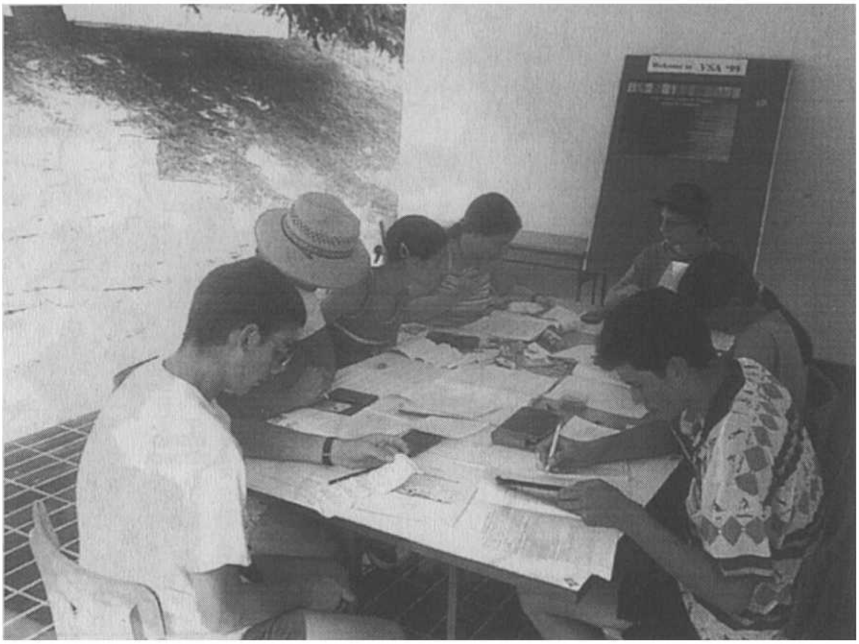


Figure 2. All the teamwork is done in a mode that is as much different from the classroom work as possible. This image shows the group for the meteor observation in the shadow of the dormitory's veranda in the "family" like atmosphere while they are reducing the previous night data.

The workshop is held in a scientific environment, but to display other realities, educational excursion to other astronomical and non-astronomical institutions is carried.

VSA has been combining scientific work with learning for thirteen years, and throughout these years it has followed many important astronomical events. The collision of the fragments of Schomaker-Levy 9 and Jupiter were followed during the VSA 1994 by various experiments. Comets and meteor showers are followed every year. The VSA does not stop in the end of those ten summer days because the communication continues with interested pupils and they can join other activities.

The majority of participants, 2/3 of them, are contacted during the "Astronomy Science fairs" in Croatia, but the workshop is open also for other 14-18 years old high school pupils from all around the world selected to fill the quote of usually 20 participants. For these other pupils, it is appreciated if their application form is accompanied by a presentation letter from one of teachers at the school he/she is attending. But the procedure is not so rigid. Exchanges of letters or interviews with one of the team leaders are enough. The spatial distribution of attendees is very peculiar and reflects more the political turmoil, front line positions, and refugee's migrations in the past decade, than the distribution of inhabitants, level of scientific culture, etc. Figure 3.)

Figure 3. The spacial and "density" distribution of attenders from the Balcan-Adriatic regions on the main educational activities at the summer workshop "Visnjan School of Astronomy" during the period 1989-2001.

Involved Croatian regions:
3. Istarska (17%)
8. Međimurska (5%)
10. Primorsko-goranska (5%)
11. Požeško-slavonska (<1%)
12. Šibenska (1%)
13. Sisačko-moslavačka (5%)
14. Brodsko-posavska (4%)
15. Splitsko-dalmatinska (5%)
16. Varaždinska (3%)
18. Vukovarsko-srijemska (<1%)
20. Zagrebačka (32%)

European Regions:
Friuli-Veneziagiulia (I) (4%)
Federacija (BIH) (2%)
R. Macedonia (MK) (<1%)
Slovenia(SLO)(6%)
Srbia (YU) (7%)
Veneto (I) (<1%)

Non involved Croatian regions:
1. Bjelovarsko-bilogorska
2. Dubrovačko-neretvanska
4. Karlovačka
6. Krapinsko-zagorska
5. Koprivničko-križevačka
7. Ličko-senjska
9. Osječko-baranjska
17. Virovitičko-podravska
19. Zadarsko-kninska

3.7. WLab Project T-1A/I "Training Students in Basic Science at the Visnjan Observatory"

This was a very important project during the period 1996-1999 when it was completely supported by the ICSC – World Laboratory organization. The pupils who have interest to continue the work initiated during the VSA summer workshop had a possibility to attend various group activities or by individual work at the Observatory during a year

3.8. Students at Visnjan and Management in Science and Education

One of the latest educational programs that are evolving at the Visnjan Observatory represents the self-organization of the former VSA/WLab workshop attendees who wanted to continue the work and organize their colleague students to join some projects.

The results of the ex VEP students' groups working together are quite impressive and the best known is the Meteor expedition in Mongolia to record electrophonic sounds and the scientific output that it is generating.

Also, the program is in part a supplement to the education of the students in the fields of education and management that are not present enough at the science studies.

3.9. Natural sciences Workshop Visnjan

The last of the workshops that initiated in 2001 is for four graders and fifth graders. The main goal is introduction to the scientific method for young, elementary school pupils. In that case, the Astronomical Observatory is just a frame because the field of work is actually stretched from arts to meteorology.

3.10. WEB – presence

The mixing of technology and sciences was the "file rouge" for the multidisciplinary approach to the activities. Computers have been important in the education of gifted pupils at Visnjan since the year 1980. Six years after the first connection to the net begun. As the Internet evolved to the web, so evolved the educational and scientific presence of the Visnjan Observatory. The newsletters (27), articles (28), books and images are accessible freely through the web.

3.11. Giving support to other programs

As the activities diversified and science projects becoming more distant from astronomy, many new personal and institutional contacts bring new ideas and are initiating new projects in Croatia. Since the dormitory and the Visnjan Observatory are in Visnjan and since they provide a kind of scientific environment, they allow to different groups a chance to come to Visnjan to organize their activities that are in part connected with the VEP. These groups range from scouts to specialized workshops such as "Daroviti prirodoslovci 2001 – Gifted naturalists 2001" organized in Visnjan by the city of Zagreb's "Peoples technique association".

4. Conclusion

The Visnjan Educational Project began to introduce gifted high school pupils to sciences in a specific time in the history of the region of southeast Europe. The project grew, diversified and changed to accommodate new needs of the pupils. A pattern of support activities and contacts was developed and maintained to run these project Figure 4.

The main educational problems that are identified during the project's duration and are partially solved or the work is still going on, are: dissemination of scientifically correct information to the public, searching the way to bypass the school system to reach gifted pupils, cope with the fall of interest for a scientific career in the post communist and post wartime situation, fall of girls participation in the "top" social activities. The scientific results and technological development produced by the involved pupils and students showed us that a gifted population of pupils needs projects and facilities where they can live in a stimulant scientific environment. The most important result for these pupils where not the first scientific measurements, results, or papers presented on conferences but the "high hopes" incentive.

The near future of the VEP will be more of the same, but with a special attention to follow the social, legislative, educational and communications changes that are going on. Also, the project must to start widening the group of volunteers and professionals involved in the project.

For more distant future, more evolution patterns exists.

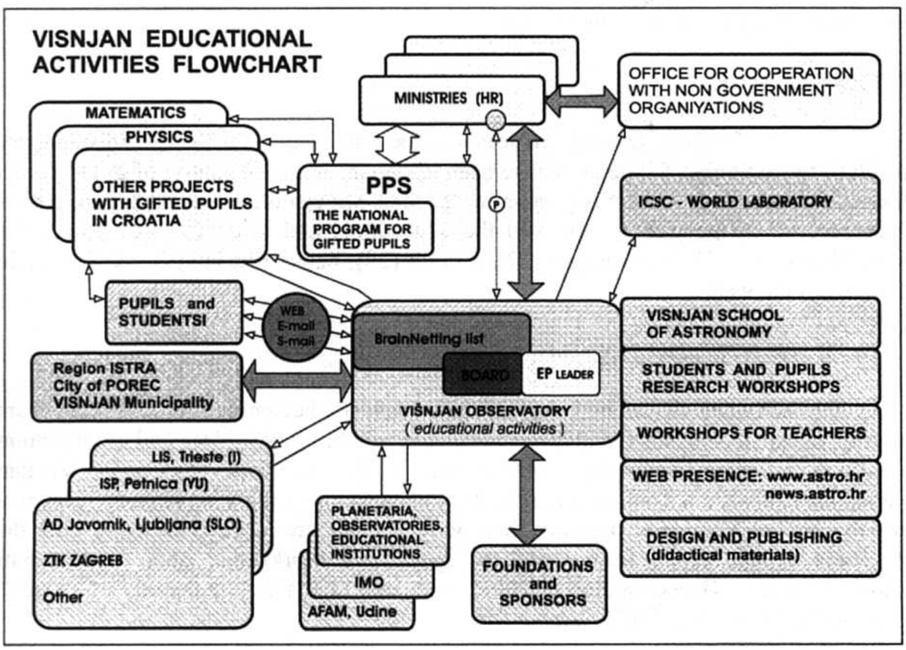


Figure 4. This flowchart of the educational activities presents the situation in the year 2001. During the last year, only the strong fluctuation in connections between the subjects was a constant.

References

[1] M. Tripalo, Communist party and the young's, *Our way*, NIP-Komunist, Beograd, 1969, 337-350 (in Serbian)

[2] S. Kavacic, Social and economical reforms end their importance, *Our way*, NIP-Komunist, Beograd , 1969, 177-207, (in Serbian)

[3] D. Rakovac et al. Communist party leadership-personal communications, 1975-1990.

[4] M. Vukusic, Social environment for the development of inventive work in Yugoslavia, *Inventivni rad*, Vjesnik, Zagreb, 1984, 37-43. (in Croatian)

[5] D. Malvic-editor., People's technique in Croatia, Narodna tehnika Hrvatske, 1986, (in Croatian)

[6] J. Lukatela et al., Out of curriculum scientific activities of youths, Narodna tehnika Hrvatske, 1982, (in Croatian)

[7] K. Marx, Capital - Vol. I , Hamburg, 1876.

[8] V. Maic, Editorial, *ISP Bilten*, Valjevo, **10** (1990) 3.

[9] Z. Ivezic, Young's academy of gifted "Leonardo"- the project, Mala akademija nadarenih Leonardo, Pula, 1990.

[10] K. Korlevic, Yugoslav Summer School of Astronomy -1989, poster presentation, International Meteor Conference, Balatonfoldvar, 1989.

[11] J. Pasachoff and J. Percy, The Teaching of Astronomy-Proceedings of the 105 Colloquium, International Astronomical Union, Wiliamstown, 1988.

[12] K. Korlevic: VAP – Proposal of the new approach to introduce gifted pupils to scientific research through astronomy in Croatia, Zvjezdarnica Višnjan, 1992. (in Croatian)

[13] A. Contin, T1 A/1 / World Laboratory Project on Training of Students in Basic Science at the Visnjan Astronomical Observatory, Proceedings of the Fourteenth Combined Project Directors' and Scientific Committee Meetings of the ICSC-World Laboratory, Lausanne, **34**, 269-284, 1998.

[14] Z. Andreic, Telescope Making Handbook, Zvjezdarnica Visnjan, Visnjan, 1990. (in Croatian)

[15] Z. Andreic and K. Korlevic, ATM-Amateur Telescope Making, Zvjezdarnica Visnjan, Visnjan, 1992. (in Croatian)

[16] K. Korlevic et al., Published a number of measurements in the Minor Planet Center's MPC and MPEC circulars, 1995-2002.

[17] A. Bedalov and B. Lukic, The Visnjan Educational Project, poster presentation, NGOs Days, Zagreb, 2001.

[18] G. Sostero, AFAM – The young's and the science, project for a new didactics, AFAM brochure, Udine, 2001. (in Italian)

[19] A. Contin, personal communications, Bologna University, 2002.

[20] M. Juric and K. Korlevic, Visnjan Observatory Image Database 2 , Proceedings of CUC 2000 Conference, Zagreb, 2000.

[21] K. Korlevic, M. Juric, Visnjan Observatory Asteroids Followup Program 1995-2000, poster presentation, Asteroids 2001 Conference, Palermo, 2001.

[22] K. Korlević: Proposal for the beggining of an Teachers Astronomical Workshop, Zvjezdarnica Višnjan, 1992. (in Croatian)

[22] M. Gerbaldi, L. Bottinelli, L Gougenheim, F. Delmas. J. Dupre: Training of school teachers at French Astronomy Summer Universities, Proceedings of the 105th colloquium of the IAU, Williamstown, Massachusetts, USA

[23] Z. Andreic et al, Astronomical Handbook 2. , Zvjezdarnica Visnjan, Visnjan, 1993. (in Croatian)

[24] Visnjan Observatory, Svemir u ucionici, (Available online at:http://www.astro.hr/ucionica) (in Croatian)

[25] T. Stimac, personal communications, 2002.

[26] N. Edmund, SM-14 The General Pattern of the Scientific Method, Norman W. Edmund, Lauderdale, 1993.

[27] Visnjan Observatory, Web Library, (Available online at: http://www.astro.hr/library) (in Croatian)
[28] Visnjan Observatory, News Page, (Available online at: http://news.astro.hr) (in Croatian)

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Specialities of Gifted Children Education in Post-Soviet Countries

Ruslan MARIYCHUK
Uzhgorod National University, Uzhgorod, Ukraine

Vasil PETRUS
Transcarpatian Institute of Advanced Pedagogic Education, Uzhgorod, Ukraine

Abstract. The present report is devoted to peculiarities of gifted children education in the conditions of post-totalitarian regime. The causes of difficulties are the feature of psychology, the absence of instruments for gifted children discovery, the absence of social demand. The science education of high school students is realised by a few ways: State Program "Creative gifts", The Young Academy of Sciences, and the systems of inter-school study groups and scientific societies. The program of The Young Academy of Sciences is a close co-operation between high schools and University research laboratories. The high school students are trained in the framework of this program, which includes several stages. The first stage is examination in the field of science, which was selected by the student. It is realised in the way of student's Olympiad. The second stage is a public defence of his research work (that is presented as thesis). The thesis preparation requires experimental and theoretical research. The scientific stage is carried on in University research laboratories.

1. Specialities of Human Psychology in Post-Soviet Countries

Despite to the attempts of democratic transformations, which have taken place in recent 10 years, the debris of values of the totalitarian regime principles remain in the psychology of people and their social and work relations.

It is obvious, that the mentality changes must measure not the number of years, but the number of generations, whose were grown at conditions of minimal pressure. There is no doubt, the human mentality is independent of the form of political system of state are form by the press, radio, television. The control of state under upbringing, education and access to information gives the possibility for formation of social consciousness.

The different norms of social behaviour and behaviour in reference groups are one of the important differences in human psychology of post-soviet country and countries of developed democracy. They are determined by upbringing in the family, school and distrust to state institutions.

The last is displayed in the dual moral - official system of values and domestic manners of behaviour. The last manners dominate in the consciousness of ordinary citizens and play the role of moral justification of asocial deeds. For example, the copying and cribs are not considered as dishonest competition. The collective guarantee can be often applied. The human, who supports the collective, becomes a collective outcast.

If in the post-soviet countries, the formation of personality and public relations is based on the sense of collectivism and associated to collective, as opposed to the states with developed democracy, the sense of responsibility for personal actions that is followed from early awareness of oneself as the individual is typical. No acceptance of any individual initiative is a negative consequence of collective principles.

This aspect is important while reviewing the gifted child's problems because they are not ordinary and social environment oppresses them (1). The collective does not like "the forward pupil"; the gifted child easily outstrips the group in the intellectual contests. It can not be accepted by "socium" which was formed on the conception of social nivellation (equal level).

The important problem of gifted child education in post-soviet countries is the absence of motivation. The components of motivation are:

1.1. Social demand

The demand in highly qualified specialists are practically absent in the condition of low developed economics. It is connected with inadequate financing scientific and research programs in industry. In consequence, we have the low prestige of scientific professions. The absence of prestige influences the selection of future profession, which a young person faces. The absence of social demand on the high quality of intellectual production leads to appearance of considerable amount of "unnecessary" geniuses. The absence of the demand for highly qualified specialists in the country is the cause of immigration phenomena.

1.2. Social defence

The training of a gifted child usually requires the teaching which uses special programs or in the special groups (or with an individual teacher). The number of special educational institutions is less than that of ordinary institutions. It leads to the necessity of attendance of geographically distant institutions.

Another way of gifted child training is individual lessons (with a personal teacher). In any case, the additional financial expenses are necessary. The problem lies in the absence of material support of gifted child education. The system of financing for teaching in the boarding schools (in big cities with profound study) practically is not developed. The number of graduate grants and their sizes are far from the necessary minimum. The majority of current foundations are of a foreign origin.

This situation leads to absence of personal interest (financial, in particular) in the results of activity. The current lows can not protect the intellectual achievements of people; the degradation of industrial basis and conservatism of technologies limit the realization of prospective projects.

1.3. Public opinion

The main problem is fear to be opposed to the opinion of the collective. The person, who rises above the collective, meets the total disapproval. It is the cause to worsening relations with the environment and it is painful for a child in the phase of personally formation. The child often conceals the fact of intensive training and the real state of his knowledge.

1.4. Family conditions

The main moments of family conditions are economic, moral and psychological situation (2). The hard economic, moral and psychological situation limits the possibility for the development of the gifted child. The absence of one of the above-mentioned conditions is not enough for normal development of a person. The good material conditions in the family and sufficient attention give the possibility for developing of natural talents.

1.5. Absence of special programs

The general problem of all educational systems of any country is the absence of not only special programs for teaching but also uncertain criteria of their formation. The causes are the giftedness seldom can occur, shown and noted together; education program must be formed in accordance with the individual demands and interests of the child (in ideal, the education programs must be personal) (3).

The influence of these factors, which were inherited from totalitarian conception of upbringing, has lately decreased. However, the conservatism of human consciousness does not give an opportunity to disregard in completely.

2. Forms of work with a gifted child in Ukraine

The main and more spread form of work with a gifted child in Ukraine is facultative. It started in 1966 and is financed from school budget.

School facultative has the following advantages:
- absence of strict programs which limit the freedom of teachers' and students' actions;
- pliancy of programs (program is formed in agreement with pupil's demand);
- psychological adaptation of students to the teacher is not necessary;
- voluntary and self-actualisation of students.

and disadvantages:
- covering limited number of students;
- absence of methodical facilities;
- teacher does not have any special training for the work with gifted child;
- no optimal time of the day (often in the evening).

Inter-school facultative covers bigger auditory. The psychological disadoptation "student-teacher" is also possible.

Circles (Hobby groups)

1. Formed at high schools - insufficient financing.
2. Stations of Young Technicians. Houses of Technical Work.
2. Stations of Young Naturalists (biology, ecology, geology, geography).
3. Stations of Young Tourists.
4. Houses of Child Art - Schools of Art;
5. PCY - Palace of Children and Youth - complexes in big cities (The so called Padiyun).

Advantages:
- pliability, in accordance with the child's demand;
- possibility of self-realisation.

Disadvantages:
- low level of fundamental knowledge;
- displacement of accents to practical application.

The special form of gifted child work is the Young Academy of Sciences, which will be shown below in details.

3. "The Young Academy of Sciences"

The Young Academy of Sciences has existed in Ukraine since 1991. The idea of activity of The Young Academy of Sciences is searching for gifted children, their involvement in research work and work with scientific literature.

The Young Academy of Sciences has a developed vertical structure. The primary divisions of The Young Academy of Sciences are arranged in high schools, municipal, regional and republican divisions.

The above-mentioned divisions exist at The Houses of Technical Art, The Stations of Young Naturalists and other non-school institutions.

The main activities of The Young Academy of Sciences concentrate primarily at senior forms of schools. Training the gifted child is carried out in a several directions:

1. Reading of introductory lectures of scientific-popular character, excursions, which must awake interest of the gifted child to certain fields of science. The aim of these lectures is widening the cognitive worldview.
2. Lessons on certain subjects with a group (in senior forms - 15 and more people) with profound course (programs composed by the teacher).
3. The research work is carried out in small groups or individuals. The teacher proposes the subject of investigation.

Requirements:

a) according to the abilities of the child;
b) corresponding to the knowledge level on the subject;
c) corresponding to the material and technical level of provided facilities.

The performed works can have theoretical and experimental character.

The results of research work must be presented as thesis (about 15 pages). The defence of research work is realised at municipal (regional) meetings of The Young Academy of Sciences. The winners of this competition are sent to higher level conferences up to the All-Ukrainian ones. The self-dependency and applied character of research work are criteria for the importance of investigation.

Privileges: last three years, the prize winners of this competition are equalled with winners of The All-Ukrainian Subject Olympiads. This status enables them to be enrolled into the State Universities without entrance examinations. For information, in Ukraine the free education system, which is financed by the state budget, exists.

Usually, research work is carried out under supervision of University professors, researchers or collaborators of Research Institutions.

Research carried on by the child in the specific atmosphere of research laboratory, in the environment of scientists and post-graduate students, has a positive effect on the students, on their social independence and self-actualisation, and raises the high level of motivation. The peculiarity of scientist's environment is the absence of psychological differentiation of people by age, fundamental and experimental level. The students do not fill difference in intellectual level with researchers because it is not a subject for discussion.

The peculiarity of scientific collective is its goodwill. These peculiarities make the referent group for the young man from scientific collective (4). The formation of the stable desire to join the group as full-fledged member (student, post-graduate student and researcher). It is important, that this wish should not only be a dream but the child should understand the ways of realisation (intensive study, widening has worldview, development of his personal talent and so on). The following solves the important and actual problems of the gifted child:

- breaking away from commonplace environment;
- scientific activity gives possibility for self-realisation;
- environment gives an example for imitation;
- possibility to free exchange of significant information.

Accordingly, provincial divisions of The Young Academy of Sciences have a weak material base.

The structure of The Young Academy of Sciences includes the following sections:

1. Physical and Mathematical section.
    1.1. Astronomy;
    1.2. Economics;
    1.3. Mathematics;
    1.4. Physics.
2. Technique and Technology:
    2.1. Electronics and devices;
    2.2. Applied elaboration.
3. Computer engineering and programming.
4. Chemical and Biological section:
    4.1. Biology;
    4.2. Chemistry;
    4.3. Ecology;
    4.4. Medicine;
    4.5. Psychology;
5. Art and philology:
    5.1. Art;
    5.2. English;
    5.3. French;
    5.4. German;
    5.5. Literature creation;
    5.6. Ukrainian language;
    5.7. Ukrainian literature.
6. Historical and Geographical section:
    6.1. Archaeology;
    6.2. History of Ukraine;
    6.3. Historical study of local lore;
    6.4. Geographical study of local lore;
    6.5. Geology;
    6.6. Law.

The competition of research work is carried on separately for every section. The winners of this competition are congratulated in ceremonial atmosphere; the results of this competition are shown in press (it stimulates the child).

Advantages of The Young Academy of Sciences as a form of science education:
1. Voluntary participation.
2. Higher level of teaching, deep program of training;
3. Presence of subjects beyond the school program.
4. Possibility advanced and accelerated training.
5. Collaboration between high schools and higher education (if not the only one).

Disadvantages of The Young Academy of Sciences as a form of work:
1. Work with a child is possible in limited number of high schools, often in cities only according the principle - one school - one subject.
2. Impossibility of organisation in countryside.
3. Absence of special training of teachers to work with a gifted child.
4. Absence of its own material base.
5. absence of continuity (the work is stopped during vacations).

4. Complex Program of searching, teaching and upbringing of gifted children and youth "Creative gifts"

The program of searching, teaching and upbringing of gifted child and youth "Creative gifts" was created on 1991 by the initiative of The Academy of Sciences and Ministry of Education and Science of Ukraine (5). The program cover practically all age groups - pre-school, primary, secondary, teenagers, senior pupils, students and junior specialists.

Main directions of activity (6):

- creation of optimal system of scientific and educational institutions, organisations and societies;
- elaboration of teaching plans, programs and text-books for the gifted children;
- advanced training of teachers for work with gifted children;
- fundamental and applied investigations in the problem of giftedness;
- organisation of workshops, conferences for consultations of teachers;

The basis of the program realisation is out-of-school institutions. Financing is realised by state budget sources, institution sources, public foundations and organisations, private sources.

5. Conclusions

Training of gifted child is conjugated with several difficulties: economical; social; academic. Although on those difficulties, search of forms of gifted child training and its optimisation is realised. At that non-traditional out-of-school forms training are used. Those specialities of gifted child training lead to encouragement, stimulation of gifted child, advancing of their social status in society.

References

[1] Nicholas Colangelo and Gary A. Davis, Handbook of Gifted Education. Needham Heights, MA: Allyn and Bacon, 1997.

[2] Benjamin S. Bloom, Developing Talent in Young People. Ballantine Books, New York, 1985.

[3] Robert J. Sternberg and Janet E. Davidson, Conceptions of Giftedness. Cambridge University Press, Cambridge, 1986.

[4] M.-A. Robert, F. Tilman. Psyho connaitre l'individu te le groupe aujourd'hui. - Vie Ouvriere. Bruxelles. 1980.

[5] Information bulletin Ministry of education of Ukraine. 1992, №3, P. 13-22.

[6] Information bulletin Ministry of education of Ukraine. 1992, №5, P. 12-25.

New Strategic Orientation of the Treatment of Gifted and Talented Students in the Republic of Macedonia

Ljupco KEVERESKI
OS Gregor Pricev, 96000 Ohrid, Velgosti, Macedonia

Abstract. Gifted and talented individuals are creators of the progress on each country. That a potential which has the biggest contribution in enriching on collection on expresses values in material and spiritual sense in each society. This paper identifies the most important points of a special program for gifted children helping its implementation in the Republic of Macedonia.

1. Introduction

The general progress of the humanity that is cause by the modern achievement in more spheres of our living continues its developing tendency. The raising of our quality level of living is inevitably brought to a correlative relationship to the care that we show to our gifted (talented) and most creative potential. On the other side the stressed interest for them in mostly inspired by the more expressed persistence to achieve hurried socially-economical, scientifically-technical, technological, socio-cultural and other development that is exceptionally needed.

Respecting the experiences of the developing concepts in the high developed and efficient education systems in the world in relation to this category of pupils, we come to an establishment that they deserve more intensive treatment in all levels and degrees of education. The need to prove higher respect is determined by the fact with the needs and development of talented pupils we can not do and make compromise.

The basis of our developing concept for the gifted and talented pupils refers to respecting their needs and individual dynamics of development of their capabilities.

Gifted and talented individuals are creators of the progress on each country. That a potential which has the biggest contribution in enriching on collection on expresses values in material and spiritual sense in each society. Therefore as an imperative before all is placed a necessity we'll search and tend these individuals in our environment. That put us in situation for each price we'll insist to stop exit on our most creative individuals in other countries.

2. The reasons for choice

- Mental models on teachers, pupils and parents in big measure determinate relation to gifted and talented in the family, school and out of them;
- With needs and development to gifted and talented we can't make compromise.
- The acknowledgement and the confirmation that gifted and talented individuals exist in our country.
- Everyday transfer of „brains" from our country.
- Aiming on social pupils and consciousness for necessity that is indispensable in R. Macedonia to enlarge practical worry and interest for gifted and talented.
- The worry for gifted and talented needs to be one of national advantages.
- Particular dilemmas and needs on instructional and other skilled personnel in the schools for that who, what, when, how, needs to work with gifted pupils.
- The change of paradigm in relation on looking on the pupils population (from average of individuals)
- The necessity on making and funneling on organized system on treating on gifted pupils.

3. Concern about the gifted and talented-primary national interest

Recently, in many countries in the world, but in the developed longer period ago, the phenomenon of talent has occupied a primal position in the hierarchy of social values. Its social, economic, pedagogic and other dimensions are often treated by experts on various domains and expertise, at the numerous professional and scientific meetings.

The following questions become more and more universal:

Are the gifted and talented sufficiently regarded and what are the possibilities to facilitate their optimum development?

Their universality initiates a sense and requirement to a related position in the sequence of national priority. Therefore, in the Republic of Macedonia, efforts are made to replace the former concept of concern and interest in the gifted and talented with clearly defined methodological proceedings and a real vision for establishment of general and practical organized system for their treatment. This necessity is moreover emphatic if we consider the phenomenon of daily transfer of experts from our country to the highly developed countries.

It is intensively insisted upon discovering the possible formula to close " ***the door exits*** " of transfer of our most creative individuals the stoppage of the " ***brain exporting*** " process is our primary continuous objective, as the most profitable and inexpensive investment. For that purpose, it is integrated into the existing social and institutional mechanism directed toward the creation of perspectives in order the intellectual potentiality to remain in our country. That means that we are making efforts to provide them opportunities to offer and realize their exclusive potential in our country. Simultaneously, they will be in a position to satisfy their intellectual, emotional, social and other needs.

4. Summary

It is certainly true that creators of the progress will be the gifted and talented, if they are given an opportunity. There is not a country whose objective is not to hasten and heighten its qualitative development. Resulting of this, the necessity appears as an imperative in front of all of as - to find and nourish these individuals in our area. The school should be a place where they can be given *„food"* which will satisfy their wishes, necessities and appetite.

The teachers who will teach them should be more: programmers, organizers, explorers, tutors, advisers, imitators of cooperative relationships, planers, evaluators, directors and other related functions.

Our aim is the gifted and talented students to acquire related scientific and methodologically based treatment which aspired to satisfy the fundamental standards and requirements. The objectives, in the Republic of Macedonia, as long-lasting treatment are moving towards the following directions:

- ***Construction of the national strategy including the treatment of the gifted as one of social primal objectives in the Republic of Macedonia;***
- ***Formulation of social, long-lasting, coordinated and detailed action - the actions and measurements will operate with a unique objective: practical realization;***
- ***Establishment of the social concern about the total treatment of the gifted on a higher national interest;***
- ***To transform the always present tendency of constructing practical, organized and consistent system of work with the gifted as an urgent objective;***
- ***Abandonment of theoretically declarative direction of treatment of the concern and interest in the gifted;***
- ***Altering the indifferent attitude of the society towards the gifted;***
- ***The social atmosphere related to the gifted should be characterized with positive examples of acceptance, respect and conditions for development of the young talents;***
- ***The establishment of an adequate treatment of the gifted should be extracted from the margins and placed on the beginning of the daily schedule. As an interest of the society this necessity has culminative degree;***
- ***Respect towards the social tendencies for altering the relation to the gifted and their institutionalizing;***
- ***Concrete lawful, normative sanctions available for the treatment of the gifted;***
- ***The innovation of the educational process with training programs and plans for the different abilities of the pupils;***
- ***The differentiation, acceleration, individualization and other kind of innovation and adoption of the training work which will contribute to the development of this category of pupils;***
- ***Developing positive institutional climate for respecting the differences between the pupils and creating such conditions which will give a chance to the gifted to find themselves and to develop their potential abilities;***
- ***Using and finding new institutional forms which will be directed towards stimulating the development and the work with these pupils;***

- ***Stimulating the thinking that the separation of the pupils in special groups, classes and even schools, goes in favor of developing their abilities and not always in the expected pedagogical, psychological and other negative effects;***
- ***Finding ways for professional training and improvement of the teachers, which will mean rising the educational ability of the teaching staff in the treatment of these pupils;***
- ***Election of a teacher who will work with the gifted pupils according to established criterions;***
- ***Electing and practicing particular motivation forms and methods for the teachers which will be stimulus to their further engagement and work with these pupils;***
- ***Stimulating the practice of school's acceleration in which, except the intellectual status, will be taken care about the emotional, social and connotative status of these pupils;***
- ***Changing the physiognomy of the classes of addition tuition.***
- ***Additional tuition on the base of tutoring principles;***
- ***Following the development of the gifted pupils through more educational stages and levels of the education;***
- ***Leaving the institutional domination of authority towards the pupils especially the gifted ones;***
- ***The fragmentary, uncoordinated institutional and individual actions should be replaced by systematic organization and well through of horizontal and vertical actions on all levels.***

How much we will success in respecting the previous suggestion depends on how fast and easy we'll liberate from the negative burden of the tradition.

The stereotype, molded thinking doesn't mean standing on one spot, but fast returning. The need of often coming over, the revision of our own opinion, thinking and behavior towards the gifted pupils should an act which will show how much and what kinds of changes are essential to us. If we continue doing ***„services"*** to the gifted individuals, with our attitude, we'll stimulate them to take their ***„wealth"*** out of our country. We should use all social, institutional and other mechanisms in order to keep the gifted in our country. At the same time the equal treatment of the equals should be the only formula, which respects the individual differences between the pupils. Indeed we'll all have bigger benefit from that.

System of Work with Gifted Children in Gymnasia No. 5, Minsk, Belarus

Eleanora KAKAREKA and Margarita KOTLYAROVA
Gymnasia No. 5,
Mendeleeva 14, 220037, Minsk, Belarus

Abstract. In the paper key features of the system of work with gifted children in the Gymnasia N5 (Minsk, Belarus) are given. Application of the theory of the inventive-tasks-decision (YITD) for development of creative abilities, research activities are described. It is shown that in the framework of the project "Intellect, Creativity, Health" the teachers of gymnasia individualize the education of every child-prodigy in the educational network.

1. Introduction

The reforming of the modern system of education in the Republic of Belarus has caused the necessity of the formation and development of both intellectual and spiritual potential of nation. In this connection especially urgent is a problem of the creation of elite secondary schools and bringing up the Belarusian elite.

The secondary schools of a new type – gymnasias – have arisen in a period, when the society with one voice began to speak about a problem of endowments, the necessity to develop the creative abilities of children. The economic gymnasia N 5 was planned as an elite educational institution focused on work with children, having the increased intellectual abilities.

1.1. General features of the system of work with gifted children

For a long time school has been paying an intent attention to children with deviations in the development. There were special schools for them and teachers prepared. And quite recently the society began to speak with one voice that gifted children demand special attention and it's not so easy to work with them. We always used to say that "all the children are bright". But how is it really possible to develop the deposits of a child, to transform them into abilities, how to develop endowments?

The system of work with gifted children worked out in Gymnasia No. 5, Minsk, and reflected in the project "Intellect, Creativity, Health" tries to answer all these questions.

Broadening of the modern information space, participation in the cultural-economic European field imposes certain obligations on system of modern education. Therefore, a person who would like to answer the modern requirements and be successful in life should count on one decisive factor – studies during the whole life.

The stereotypes existing in school system of our state often result in non-development of the deposits and abilities of students in the conditions of the school conveyer.

The main brake for the development of creative beginning in a child is the restriction of the creative environment and activities carrying positive emotions at school, absence of an atmosphere of approval and understanding in families, replacement of internal motivation by external, i.e. a mark. Besides the schools are the most conservative public institutions, and both the offered pedagogical receptions and techniques add to the stresses. Taking into account all these moments, we have defined for ourselves the purposes, tasks, stages of realization of the project in time. Our overall objective in work with gifted children – to teach the students to study, to offer them methods of scientific learning with the help of which they can extract knowledge themselves.

But before to speak about the system of work, it is necessary to define what we understand under the concept “endowments”.

Very often we substitute the word “endowment” by the words “capable”, “very capable”. But this understanding of endowments only as intellectual characteristic of the person does not correspond to the genuine understanding of the high development of the person’s opportunities. Normally it is not the human mind that is gifted but the person himself. Therefore the main objective of our work is the organization of such joint activity of the teacher and the student where the non-standard vision of the world, non-stereotyped way of thinking would be formed, and the linking bridge between the deposits and the abilities would be the creativity. And these components as a matter of fact are the real endowment.

To achieve the mentioned above tasks it is expedient to use the following approaches for the development of the creative personality.

1. Education of the qualified pedagogical staff for the work with the gifted children which includes creative-stimulating and health-protecting technologies;
2. Normalization of the amount of work to be done;
3. Creation of an Educational Center for parents;
4. Creation of non-stop education “kindergarten-gymnasia-university”.

The conception of gymnasia education is the basis of work with the gifted children. The gymnasia was created as an economic one, that includes profound studies of mathematics. But our purpose is to bring up an all-round educated person. That’s why a musical, art, dancing schools were opened in the gymnasia. And a child chooses whatever he or she likes. Sometimes children study music, dancing and arts at a time. But in this case we can’t say that a child is overstrained because he or she does it with pleasure and is full of positive emotions. Cooperation of psychologists, curators, teachers lets find out gifted children. The next step is the creation of home-like atmosphere at the lessons.

From the other side the teachers use new pedagogical technologies, orienting students for success. The main components of modern education are:

1. The level of competence of a student;
2. Ways of activity;
3. The experience of creative work;
4. Moral values.

Teachers often use the first two components. But they often omit the experience of creative work and moral values, status requirements, in other words children's inborn curiosity, their desire to communicate, their position in a group. These requirements cannot be satisfied in a system at explanatory-illustrative technologies, where the creative activity bearing positive emotions is limited. Anxiety rises the child's health worsens, there is no strategy of the successful personality, schoolchildren cannot realize themselves. Secondly, the use of the technologies motivates the activity of the child. Modern researches consider the key characteristic of the personal potential to be not only outstanding intellect and high creativity but motivation itself.

The spectrum of the technologies used in the gymnasia is rather wide. This is the technologies on the organization of the group and individual mental activity at Physics supposing mass involving of the schoolchildren in research activity, the theory of the inventive-tasks-decision (TITD) at Geography, Astronomy, Biology, removing fear of the new and assisting the children to solve creative tasks; modeling at Mathematics; project technologies and debates at lessons of the foreign languages; "Alphabet" and "Creative studio" technologies; technologies of developing cooperation in elementary and secondary schools; adaptive system at World History and History of Belarus; technology of multi-level control of knowledge and skill estimation in all subjects. Using these technologies we could find the connection of intellect and creativity, realize that far not every activity develops inborn inclinations, but only the one that results in positive emotions and high motivation. But only a teacher can lead to such an all-absorbing activity, the teacher who doesn't impose his personal opinion but a manager leading the class and assisting the schoolchildren to grow up to new semantic levels.

2. Application of the theory of the inventive-tasks-decision (YITD) for development of creative abilities

Some words are to be told about TITD which is one of the most effective technologies of development of creative abilities. As a science, TITD appeared in the 40-ies, when a young Soviet engineer G. Altshuller started his work on the problem of searching of inventor's thinking activation methods. TITD has certain instructions helping every person in solution of non-standard tasks. Having possessed those instructions the schoolchildren solve research and creative tasks at Physics, Geography and Biology. As a result at TITD methods application the psychological fear of the new is removed. The schoolchildren are not afraid of both educational and vital tasks but what is more they are eager to solve them. The psychological inertia of thinking is overcome, the motivation of knowledge amplifies, as the schoolchildren solve useful and significant tasks for them.

3. Research activities

The following block is a research activity. We include here first – school scientific community, promoting mass involving of children's occupation with science. Secondly, the individual work with the gifted children leading them to subject combinations and tournaments; thirdly, intellectual marathon, and finally, gymnasia-based practical training center for the teachers and class tutors. As a matter of fact our gymnasia is a consulting center where any teacher can be consulted.

The activity of the scientific gymnasia community is a mass involving of the schoolchildren into scientific creativity. Each age group of the schoolchildren has its scientific-didactic tasks. For the junior schoolchildren they are: skills to work with literature, to write and to make out the abstracts with the elements of experimental work; for the senior schoolchildren they are: experimental and research activity which is carried out together with the gymnasia teachers, the National Academy of Science and Universities. The result of our work is the awards at conferences and tournaments. Our schoolchildren are the prize winners of urban, national and international (Obninsk, Russia and Eindhoven, Holland) competition of research works.

The schoolchildren are engaged into experimental and research work in the field of High Mathematics (open task solution), Physics, Programming , Ecology, Biology. Sometimes the work is under control of the children teaching each other, in other words the senior lead the junior. The experience of organization of joint research activity of both the psychologies and the schoolchildren is to be taken into consideration. Each child can choose the problem to be carried out according to his/her personal interests. But at the same time this problem does not fall outside didactic policy of the gymnasia, i.e. the side between activity of the psychologists, teachers and schoolchildren is erased. At special courses the psychologists train children how to conduct an experiment, then the research is carried out, processed and the children make conclusions and report on them on pedagogical and scientific–didactic sessions. The experience of organization of Humanity research work in the field of History, Russian and Belarusian Languages and literature as well as foreign language is also to be taken into consideration. Each language is the reflection of the people's mentality and the barrier of its cultural priorities. That's why the topics chosen for studying should be significant for a child himself, e.g. a family tree, the history of Minsk city, the activity of famous people and the World War II. The children work together with their teachers in the museums, archives, go on excursions.

Leading the gifted children to subject contests is carried by the individual plan of the teacher, psychologist and class tutor specially made for a gifted child. We often involve the specialists from the Universities and The National Academy of Science. The individual plan is to be done considering the school curriculum of the child and his health condition. During the period of preparation for the subject competitions the child is given free attendance of other subjects. The psychological training is a compulsory point of the plan. It presupposes the relaxation, stress-moving and program balance trainings. The result of the joint activity of the psychologist, teachers, scientists is the result of the competitions.

4. Scientific work organization

The important point of our work is owning the theme of a scientific work by teachers working with the gifted children. The gymnasia teachers publish their own books and didactic material.

In addition to the scientific work there's a separate block of extra education. It includes free-choice extra courses for the pupils of 1-11 grades. We point out three main streams.

1. Extra courses on economics (1-4 grades – introduction; 5-11 grades – the basis of the consuming culture; 9 grades – basic course; 10-11 grades – securities, personal business organization, basis of enterprise, the strategy of a successful personality, Business English).
2. Extra courses on Mathematics and Physics.
3. Extra courses developing psychological and valeological man-culture ('To succeed', 'Will, thinking and self-education', 'Image of a businessman' and 'Valeology'.) After graduating the gymnasia the special certificate is given which allows the children not to take exams on these courses. Besides, every teacher conducts an extra course on his/her subject which satisfies the pupils demands on extra information, which is out of the curriculum.

Education of parents is a very important moment in work with children –prodigies. School stops being just a place where parents send their children to be kept and looked after. Alongside with teachers, modern parents want to take part in the development, upbringing and education of their children. With this purpose a Center of Education was created in our gymnasia. Group and individual work with parents is carried out here which includes lectures, seminars, business and role games. All of that is important for understanding one's role and its meaning, for creation of the atmosphere of encouragement and supporting of the child in the family, for protection of his/her health.

Thus, in the framework of the project "Intellect, Creativity, Health" the teachers of our gymnasia individualize the education of every child-prodigy in the educational network of gymnasia, region, city and state.

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Care for Future Scientists within the Education System in Slovakia

Jolana LAZNIBATOVÁ
Skola pre mimoriadne nadane detia gymnasium,
Teplicka 783102 Bratislava, Slovakia

Abstract. In the paper a summary is given on the Slovakian education forms for gifted children with special emphasize on the growing chain of schools for exceptionally gifted children.

1. Education of scientists: supporting talent and understanding of the public

As in most countries, gifted students in Slovakia are concentrated mostly at secondary schools, i.e. at 4- or 8-year schools - grammar schools, and universities too. The potential of gifted pupils is usually supported by form of preparations for competitions in math (*olympiads*, *pytagoriads*, SEZAM, KLOKAN, MAX, etc.), information science, physics, chemistry, biology, geography, as well as foreign language competitions. In Slovakia, classes with extended math curricula were gradually formed, as well as classes for natural sciences, foreign languages, sports, and art. The public opinion favors these types of schools, because parents (mostly in big cities) perceive education as something really significant. They are even prepared to pay more for exceptional lessons of foreign languages or other subjects, if their child has exceptional abilities and specific interests in some areas. In the last decade, students of grammar schools achieved very good placements mostly in math, information science, chemistry and physics. Preparation at grammar schools (4-year or 7-year studies) is rather focused on independent works, mostly by form of projects. Other form of students' outputs is the so-called student scientific activity – SVOČ, where students solve theoretical and scientific topics from preferred areas such as economy, ecology, biology, medicine, chemistry, geography.

2. School for Exceptionally Gifted Children

One of the new forms of supporting gifted children and youth can be seen in the activity of School for Exceptionally Gifted Children and Grammar School, which exist since 1998 (classes for basic school exist since 1993). Children identified by multiple psychological screening methods concentrate here, they are examined by means of standardized IQ tests the results of which allow them to be included into ERIN educational program for development of intellectual giftedness.

The school has the following goals:
- to develop the above-average potential of the gifted
- to support emotional and social area
- to make corrections in problem areas (developmental disproportion, asynchronous development)
- to develop universal natural activities of interest
- organization: to work on the basis of development of higher levels of thinking and creativity in the academic area

In the classes, we work with a reduced number of pupils (15) and professionals – university lecturers work with children, too. We do not classify pupils, we are not giving them marks, but the system of points - percentage valuation is used, i.e. verbal valuation and system of credits. The school is focused on the development of intellectual potential in children at age of 5 to 18 years. The form of a daylong care for pupils is used. In the afternoon, various circles are available – lego, yoga, ecology, graphic arts, ceramic arts, various sports circles, foreign-language circles, conversations, chess, photography, journalism circle, cooking circle, etc.

The principle of work at school is: Pupils will mostly get difficult tasks, unfinished tasks, creative tasks, problem-solving tasks, are engaged in training of mind processes, training of higher cognitive functions. Special attention is paid to "warming-up", to tuning to the teaching activity by forms of communities (15 minutes everyday before teaching). The topics that children solve everyday have a certain character, for example, for 4th grade of basic school – what would happen if:
- the gravitation was lower?
- earth rotated about its axis more slowly?
- earth was farther from the sun?
- Mars was inhabitable?

English language, information science, and an independent subject called "enrichment" (a complex view of one topic – universe, animals, seas, oceans, transportation, traveling, etc.) is taught since the first grade. Children make independent works already in the first grade and every school year they finish by completing an annual work with topic of their voluntary choice.

Projects: students of higher grades of grammar school make projects (3rd and 4th grade). The basic principle is teamwork. At the beginning of the year, they receive topics from which they choose what corresponds to their "abilities, interests and orientation". For example, this year the topic for the third grade of grammar school was Water and to it relevant sub-topics:
- world floods (subjects G,D,B,Sj,Cj)
- water supply (D,F,Bi,Cj)
- the world under water (B, Ch,F,Ej)
- discoveries under water (I, F,Ch,B)

Five pupils contributed to every sub-topic, every pupil from his/her own perspective.

The fourth grade chose the topic: Contradictions in the 20th century; the sub-topics were:
- World War II (D, languages)
- Wonderland – USSR (G,D,Sj,Cj)
- Atomic energy (F, Ch, B,D, languages)
- East *vs.* West (D,B,Sj,Cj)
- First leaps in the universe (D,F,B,Ch,Sj,Cj)

Three pupils cooperated in this topic. They worked with Internet, encyclopedias and, if necessary, consultation with pedagogues was employed. Totally, five mornings were devoted to the preparation of projects and consultations. The students' prepared work was published in a booklet and they presented their topic on March 27, 2002 before a wider public – parents, schoolmates, pedagogues… The goal of the project works is:
1) to teach pupils to work theoretically and scientifically (research)
2) to know how to search through literature and the Internet
3) to cooperate in teams, be able to manage a topic
4) to verbally represent own work and be able to answer questions of the auditorium
5) to systemize information and apply knowledge gathered from various scientific subjects
6) to learn fundamental principles of scientific-research work

For these children, we also prepare new teaching texts, curricula and supplemental textbooks for exceptionally gifted students. The school puts emphasis on a highly individual approach, i.e. it regards student's individual style and pace of work.

3. Conclusions

The realization of the ERIN model is officially supported by the Ministry of Education of SR, which approves a form of a differentiated and specialized approach to gifted and talented individuals. Since the teaching plans and curricula were already officially approved for this model, the whole educational program could be also extended to other cities in Slovakia – Nitra, Košice, Rimavská Sobota, Prešov, Ružomberok, Topoľčany, Šaľa, Poprad, Trenčín and, too, Levice, Žiar nad Hronom and Bytča this year.

Comment: In regular schools where 30-36 pupils are in the class (grammar school), it is very difficult to work individually with talented pupils and students. Approaches of pedagogues are too formalized, they do not have time and room to pay individual attention to exceptional pupils, furthermore, they are "overflowed" with information of a general character – which is typical for grammar-school form of a study - and students do not have a possibility to focus on (with some exceptions) their dominant area (humanity direction, natural-science), but on the contrary, they must undergo the whole teaching as required by the state school. Parents rely on the quality and a good name of grammar school, since the state education resort, even in spite of financial problems, has still maintained a relatively high level of quality.

Professionals – pedagogues and psychologists mostly maintain the opinion that it is necessary to prepare better conditions for education of future scientists, experts and professionals in the system of basic school to university. Changes should pertain not only to better material-technical capacities, but also mostly to curricula and reorganization of the valuation system. Relevant changes must be done in training of competent teachers and in preparation of new teaching programs – accelerating and enriching programs.

The new concept of the school should be changed from giving encyclopedic knowledge to humanity, non-directive creative active methods of education with regard to exceptionality of personalities mostly in talented and gifted pupils and students.

Session V

Social Environment of Science Education

Young Talents and EUREKA

Otto F. JOKLIK
EUREKA International
Gersthoferstrasse 120, A-1180 Vienna, Austria

Abstract. Young talents' recruitment for the forth coming 51[st] Brussels EUREKA, World Exhibition of Innovation, Research and New Technology – JUNIOR INVENTOR OF THE YEAR AWARD

SEARCH FOR YOUNG INVENTORS FOR A BETTER WORLD OF TOMORROW!

1. Introduction

On 8 March 1952, the first International Inventors' Exhibition was organised by the Belgian Chamber of Inventors – the oldest institution in the world dealing with the promotion and defence of inventors and innovators since 1875. World Exhibition of Innovation, Research and New Technologies or "Brussels Eureka" has been a springboard for many commercial successes and seen the conclusion of many contracts for assignment of licenses. Some 1,000 patented inventions are presented every year to the International Jury and prestigious prizes are awarded to the inventors.

Brussels Eureka is an annual meeting of the leading specialists in research, creators of new technologies, the most important associations of innovators and inventors, technology transfer professionals and official bodies that register applications for patents, trademarks and models. A meeting place for the people who are designing our future for the benefit of Humanity.

According to my knowledge there are very few, if any, inventions presented by young inventors' age 14 to 20 years old. This unsatisfactory situation may be due to insufficient information, lack of financial support and language barrier.

Consequently, due to the international characteristic of the establishment and its extensive world-wide network, Brussels EUREKA has become synonym of EUREKA International. New national initiatives and nodes are created world-wide to serve increasing numbers of applications and facilitate the final selection process. Therefore in 1999, the author suggested the foundation of EUREKA International as extension of Brussels EUREKA to include other activities in particular the high-tech sector.

In 2002, the author organized a program for assisting young inventors 10-20 of age in view of bringing their ideas for further development of their inventions to a finished saleable product through provision of detailed information, adequate advice in intellectual property protection, financing, product and project management and participation at the Brussels EUREKA.

At the local level, individual educational institutions will organize young inventor clubs / circles. At the national and international levels they organize competitions to select national winners. Among them the winners of the country's "Junior Inventor of the Year" shall participate at the annual Brussels EUREKA to present their inventions and compete for the "Junior Inventor of the Year Award". Sponsors from the industry and individuals will assist the winner in the realization of his/her invention.

2. The Invention

Every invention is the result of creativity which, in turn, is a result of fantasy, intuitivism, imagination and, in some cases, also by coincidence. This has been described already long ago by Henry Thomas Buckle (1821-1862) as follows:

"There is a spiritual, and for we sought a spontaneous and uncaused element in the human mind which ever and anon, suddenly and without warning, gives us a glimpse and a forecast of the future, and urges us to seize truth as it were by anticipation."

Every invention requires a profound knowledge not only in its own field of specialization, but also of related disciplines. The interest and experience is the basis of creativity. Every invention must have as final objective the improvement of the quality of life.

The following criteria for assessment and evaluation of its feasibility for final implementation:

- Technical effort grade of innovation
- Technical feasibility
- Commercial feasibility and market suitability
- Ease of production
- Improvement of quality of life
- Impact on social development and jobs creation
- Environment protection
- Ethical consideration
- Intellectual property protection, patent and in general ...
- Increase of the social and economical and technical standard of the country.

3. The Objectives

The primary objective is the stimulation and increase of the young inventors' creativity. This will be achieved by the method "La performamtique humaine" – Increase of Human Performance – developed and successfully applied by Vitalie Belousov, Professor of mechanical engineering and former Rector of the Technical University of "Gh. Asachi" in Iasi, Romania. The creativity of his students has been substantially increased with the consequent increase of the number of inventions and patents by his students. The cooperation of Prof. Belousov in this project has already assured the cooperation with renowned universities and colleges as well as other institutions in Poland, Russia, Ukraine, Belarus, Romania and Moldova.

Particular attention is given to activities in East and Southeast Europe to increase the profitability, productivity and expansion in the sector of small and medium scale industry in accordance with national development programs. Another objective is the information on intellectual property protection including information concerning patent specifications and applications, licensing, royalties, joint ventures, risk capital, available financial resources and the like.

Another objective is the training in basic economy, market research, marketing, and observation of competitors, public relations and personnel management.

The final objective is to assist the young inventor to carry out his invention by an adequate project management from the idea through the laboratory and pilot plant stage up to implementation by erecting of an industrial production plant.

4. Range of Services

In cooperation with the Virtual Technology Centre (VTC), the program here presented offers the following range of services:

The participants of the program are required to register as member of the Hall of Talents created within the secure zone of Virtual Sphere for this purpose. Access through the gateway to the "Hall of Talents" and to the individual inventors shall be governed by security system through the Trust Centre and Clearing House for all request and transactions.

Temporary access may be granted to partners alike for the use of Virtual Communications Infrastructure (VCI) for collaboration with members e.g. utilizing information systems, Virtual Office, language services and conferencing facilities. Currently, access to the Virtual Sphere's Private Backbone (without peering partner) is offered via secure-IP direct dial-in available in more than 60 countries with more than 2,600 nodes world-wide. These services are developed and provided by VTC and Virtual Inc.

The use of this network will enable young inventors with all the information and instructions pertaining to the increase of their creativity to accompany them during the implementation of their ideas and inventions.

5. Conclusions and Recommendations

It is evident that the deficit in the creativity of young inventors is a serious handicap for the scientific, technologic and economic development in the East and Southeast European countries and especially for the development of the small and medium sized industries which are the backbone of development of each national economy and in their struggle for the approach to the economies of European Union countries. A professional consultancy and assistance should be provided to increase creativity and capacity of young inventors, especially in the field of applied science and technology.

The ways and means to achieve these objectives can be specified as follows:

- Organization and constitution of young inventors' clubs or circles at the individual educational institutions with support of the national educational authorities, university students association and collaboration with national inventors associations, chambers of industry and commerce, ministries (national development plans), national patent offices, and the like.
- Intensive information of young inventors in all aspects of creativity increase, intellectual property protection, market research and marketing, public relations, workshops and seminars using the existing network.
- Elaboration of the conditions of a national competition to identify and select the candidates for the Brussels EUREKA's Junior Inventor award to be awarded to the JUNIOR INVENTOR OF THE YEAR at the Brussels EUREKA in November each year.
- To find sponsors for the identified candidates for their further studies and further research activities.
- To organize the support of renowned scientists from universities, academies of sciences, research institutions, and the like for training of young inventors in their own specialized field.
- To organize the visit of winners of the national competitions to annual meetings of the Nobel Prize laureates in Lindau/Bodensee in Germany.
- To organize the pilot plant project to demonstrate the feasibility of the program in question with suggestion for future improvement.

Virtual Technology Development and Transfer – Hall of Talents

Janewit PITAYATARATORN
Virtual Technology Centre (VTC)
Bartensteingasse 1, A-1010 Vienna, Austria

... On Time and Space – Virtual Sphere – Virtual Technology – Virtual Enterprise ...

Abstract. Virtual Technology Centre (VTC) addresses the important issue of creating Virtual Sphere for research, education, business, finance, governance system and more – thus anticipating the Future of Space where major human and non-human activities will take place and interact, including inter alias transformation process with the biosphere. Using current robust and proven technologies and know-how, it is possible to create state-of-the-art Virtual Network and Communication Infrastructure (VNCI) for realization of a Virtual Sphere. VTC and EUREKA International recommend the creation of a "Hall of Talents" for gifted youth as a secure universal space for the development, creation and realization of their visions. Sponsors, mentors, tangible and intangible resources – all provisions would be managed, traded, merged, and transformed as required. A pre-selection process will ensure successful "Talent Recruitment" of qualified and gifted youth with ideas, visions and innovations that will have high impact on future development of science and technology. Successful candidates shall be allotted with resources necessary for the venture and realization. The results of which will be exhibited at the Brussels EUREKA's Annual World Exhibition of Innovation, Research and New Technology. Virtual Technology Centre and EUREKA International cordially invite the participation of institutions, companies and individuals as sponsors/partners/collaborators/etc. for the realization of the "Hall of Talents". Only through concerted efforts and with your cooperation in putting together the required resources, success can be guaranteed and thus benefiting all concerns.

"Keep it simple,
as simple as possible,
but no simpler." (Albert Einstein)

1. Introduction

Opportunities arise basically through contacts, yet it is up to ones ability to exploit them for *own or mutual benefits!*

2. About Virtual Enterprises Association (VEA)

Found in Vienna in 1994, VEA is an international organization for research, development and establishment of virtual enterprises with strategic partners world-wide. VEA serves as "umbrella organization" for a suite of enterprises/institutions collaborating and sharing resources across networks for mutual benefits. Our ultimate goal is to create best possible collaborative framework for a Virtual Economy of the 21st Century.

3. About Virtual Technology Centre (VTC)

Incorporated in the UK, VTC is a privately held company founded in 1999 pursuance to the Virtual Enterprises Association's (VEA) decision to spin-off its commercial activities in the fields of technology and design. VTC is a rapidly growing network of leading technology consortia (R&D institutions, universities, companies and experts) collaborating and sharing resources across the network.

Pioneering the ***"Virtual Sphere Technology"***, VTC is uniquely positioned to address a growing commercial demand for the creation, integration and realization of the ***Virtual Sphere***. Such emerging technologies will have a potentially crucial impact on the way we live and do business in the very near future. Virtual Technology represents all disciplines of technology, knowledge and know-how in form of intangible resources ready for transformation in both living spheres. Virtual Technology is shaping the way we conduct our business in the Net – a step ahead of the "multi-trillion dollar-a-year e-Business"!

4. VEA's Philosophy

Our Enterprise's Philosophy reflects concern for the future – Living and working together in the present environment and in the Virtual Sphere for common good. By establishing the Virtual Network and Communication Infrastructure (VNCI) for a collaboration, we seek understanding and harmony with individuals, society, and work toward a society in which everyone can enjoy improved communications, well-being and affluence. We believe it is an enterprise's responsibility to respect the earth and the nature, nations and regions, societies and citizens, and seek mutually rewarding relationship. By doing so we all gradually become a Global Citizen with much lesser prejudice, delusion and conflicts. This kind of philosophy is essential for an enterprise to survive and thrive into the no-frontiers' 21st Century.

However, there are several imbalances that are obstacles to this philosophy. Firstly there is trade imbalance between certain industrialized countries. The second is the huge gap in income between developed and developing countries. Finally, there is imbalance in the natural environment (endowment), between what we have inherited and what we are leaving for the future generations. We believe that by creating VNCI for enabling Virtual Enterprise will help eliminate these imbalances and create unlimited intangible resources to supplement our current economic constraints.

VNCI provides platform for a complex heart-to-heart and mind-to-mind communication – thus promoting true understanding among the parties concerned regardless of cultural background. As the communications and information infrastructure becomes more sophisticated, the interface between people and technology increases in importance – and communication between people improves.

5. Creating Intangible Resources

The Tangible Resources (the physical dimension): as you all know! The Intangible Resources (the spiritual dimension): knowledge, experience, culture, language, history, intellectual property and endowment, etc. The Knowledge based enterprises and society need competent people with vision! *If properly promoted and exploited, Young Talents represent the unlimited resources for future innovations and output!*

6. Creating Resourceful Virtual Sphere

The inhabitants – Young Talents as the generator of innovations in their respective fields represent Virtual Economy of Scale when properly exploited! The conversion processes (harmonization and transformation) – Virtual ⇔ Reality, can take place if necessary.

7. A Three-Tier Continual Processes

Towards c-Profit (conventional-Business) as you all know

Towards e-Profit (electronic-Business) you need:
- REIN (Resources and Environment Information Network)
- Assessment and valuation of the status quo
- Provision and transformation
- Fulfillments, profits, increased values, etc.

Towards v-Profit (virtual-Business = Wisdom Society)
- VNCI
- Virtual- Enterprise/Organization/Governance/etc.
- Fulfillment
- Conversion process v-Profit to c-Profit (c=conventional)

8. Hall of Talents – The Infinite Power of Innovations

EUREKA International, VEA and VTC invite the participation of key strategic partners such as the NATO, EU, UNESCO, renowned research centres, universities and industries, for the creation of a virtual Hall of Talents and provide necessary resources for realization of innovations resulting from the Initiative. This way we are certain that the highest potential can be leveraged as v-Profit for all concerns! Define your roles/relationships and take part e.g. as mentor, sponsor, promoter, contractor, resources exchange partner, etc.

The Hall of Talents is a meeting point of organized subjective intelligent powers where tangibles and intangibles conference of resources taking place and where transformation and fulfillment's in objective terms can be met.

The project "Hall of Talents" will

- Provide collaborative framework for scientific research, education and training projects worldwide.
- Promote young talents in Central and Eastern Europe within the context of Europe Inc. Initiative for the extension of Europe.
- Assist in the recruitment process for selection of innovations from young talents for exhibiting at the 51st Brussels EUREKA – World Exhibition of Innovation, Research and New Technology.
- Promote regular contacts and meetings with inventors, promoters, mentors, universities, research centres, sponsors and industries.

Young talents qualified for entering the Hall of Talents represent high potential values ready for further deployment, development, promotion and exploitation. It constitutes symbolic assets and forms the basis for negotiation with sponsors and their mentors. EUREKA International, VEA, VTC and partners shall assess, valuate and organize investment forums for financing of those activities.

9. Design

Provision of suitable individual design in space, time and other dimensions are essential for the living and working conditions of Young Talents in the Virtual Sphere. It will facilitate maximum creativity and output. A space in the Virtual Sphere, in the Hall of Talents is reserved for young talents! Use it as your new living space for:

- Communications
- Collaboration
- Coordination
- R&D
- Transaction
- Transformation
- Entertainment
- Contemplation and meditation
- and more …

10. Access Technology and Networking

The interaction and communication with the Virtual Sphere require symbiosis of space and time design. VTC's Virtual Communication Infrastructure (VCI) provides spatial configuration for access using IP-based global secure Virtual Private Network (VPN) via frame-relay backbone (no peering partner) with currently more than 2600 dedicated dial-in numbers in over 60 countries. Users will have simultaneous access also to secure mail, files repository, conferencing, multilingual information and navigation system, e-commerce, and other value-added services. Virtual Network Architecture (VNA) is created for enabling collaboration with both Virtual and Public spheres. VNA provides tools for visualization and management of the entire networks relationship.

The term Network refers to e.g. network of:

- Peoples
- Companies / Organizations
- Governments
- Products and services
- Contents and documents
- Objects
- Key-terms
- Project partners
- Patent applicants and classes
- Micro organisms
- And even virtual beings/organizations/etc.!

11. Virtual Lab

Provision of design, planning and logistic for

- Simulation and implementation of a real laboratory environment with access to real resources whenever required.
- Cooperation with research centres, universities and industries.
- Virtual Manufacturing: collaborative platform for realization of ideas with on-demand real manufacturing output.

12. Mentoring, Coordination and Realization

- Provision of real and virtual private meeting facilities for mentors and mentees to meet and work on regular basis.
- Coordination and management of resources to specific needs of each projects.
- Realization of product/output cycle: conception, design, planning, prototyping, testing, evaluation, feasibility and market studies, improvement, production, marketing and sales, feedback – and again start of new product cycle until the objectives are met.
- Creation of new values (profits): the win-win undertaking for all participating partners.

13. Conclusion

Virtual Technology Centre, Virtual Enterprises Association and EUREKA International cordially invite the participation of institutions, companies and individuals as sponsors/partners/collaborators/etc. for the realization of the "Hall of Talents". Only through concerted efforts and with your cooperation in putting together the required resources, success can be guaranteed and thus benefiting all concerns.

As mentioned, Young Talents represent already substantial values to start with. Let's us build a proper environment for them to thrive and produce results that will benefit the sponsors, promoters, mentors and the society as a whole. Your cooperation and contribution are hereby requested. Thank you!

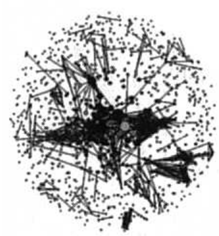


Figure 1: Each dot in the "Hall of Talents" represents one young talent packed with resources

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

The International Forum of Young Scientists – a UNESCO initiative

Diana MALPEDE
UNESCO, Science Analysis and Policies Division, Science Sector,
B. P. 3.07 Paris, 1, rue Miollis, F-75732 Paris, Cedex 15, France

Abstract: The article deals with the complex issues concerning the younger generation of scientists. It provides information on the International Forum of Young Scientists as an experimental approach in working for and with young scientists.

'Now I am old my teachers are the young....
I go the school to youth to learn the future'
(Robert Frost)

1. Introduction

The wisdom of the early planners in including science (the "S") in UNESCO's mandate has been amply demonstrated. Science has become a major force of change, never has it been so powerful and influential. The future of humanity depends critically on the continued vitality of science and its applications. They have contributed immensely to society continually modifying and improving conditions in all areas of life, such as–health, transportation, communication, education. They can offer effective means for solving many of the problems, which face humanity such as, for example, eradication of poverty. The development of biotechnology will play an increasingly important role in strengthening food, water and health security.

Day by day humanity is increasingly dependent upon S&T. But, what is paradoxical is that although our society depends on science, as never before, what scientists do remains an enigma for most people. Charles Percy Snow, in his seminal essay The Two Cultures described 'Literally intellectuals at one pole at the other scientists: between the two a gulf of mutual incomprehension.' The late American Astrophysicist and renowned popularizer of science, Carl Sagan (Carl Sagan, *A Demon Haunted World*, 1996) "We have arranged a global civilization in which most crucial elements profoundly depend on science and technology, have expressed the same sentiments. We have also arranged things so that almost no one understands science and technology. This is prescription for disaster. We might get away with it for a while, but sooner or later this combustible mixture of ignorance and power is going to blow up in our faces".

The acquisition of scientific and technological knowledge and skills is thus an imperative. In the current context of rising inequalities in all part of the world, today more than ever before, science education, beginning with scientific and technological literacy for all, is a fundamental priority.

2. The context

The developmental context for science and technology education has drastically changed in the last decades. The vertiginous rate at which science and technology has progressed has certainly afforded untold benefit to humanity, but at the same time it has also created condition and situation of an order unknown in human history.

The advances made in the last years in the genetic manipulation, in biotechnology hold out extraordinary prospects for mankind as a whole and for the individual. However, these advances raise extremely complex issues regarding the inviolability of the human being. They may also lead to excesses of all kinds- eugenics is a striking example. They give rise to important new ethical issues, which concern society.

Societies aware of these developments are increasingly concerned about how scientific progress is being used and about the risks and harms caused by technological development. While expressing an overall positive attitude to science and technology, the public at large is nevertheless becoming more and more concerned about the risks associated with scientific and technological developments. Certain disillusionment has been observed in some sectors of the society about the goals and the potential of science. In spite of a steady development that pushes back the apparent limits of our knowledge, doubts are expressed about the intrinsic beneficial function of science and knowledge. The Janus face of science has always balanced the potential benefit with potential treats, but it is in our day that the application of knowledge, such as genetics and information technologies, can seem threatening and causing widespread concern to a broader public.

It may be asked whether we are entering in the beginning of a new age of science. This new age is characterized by a number of serious challenges for science itself such as:

- finding an appropriate balance between public and private funding of R&D efforts;
- responding a new environmental and societal demands that require a reorientation of R&D efforts as well as new approaches;
- integrating both the infra-national and supra-national dimension;
- coping with human resources shortage;
- ensuring an adequate infrastructure for the development of new technologies as well as free flow and exchange of scientific information;
- understanding and managing the complexity, uncertainty, (what Ilya Prigogine calls "the end of certitudes");
- finding new form of interaction between the scientific community, policy makers and society and new institutional arrangements between the different areas of government necessary to improve science and technology policy's coherence and consistence;
- creating participatory process in science involving a large number of partners, including the younger generation of scientists;
- integrating future, creative, non-linear thinking in education and decision making;

- developing new paradigm in training scientists, engineering and innovation managers in the multidisciplinary, which differ significantly from the trend to train specialists.
- creating multidisciplinary teams and programmes, often a sine qua non condition for significant progress in areas requiring the joint work of scientists in varied disciplines,

In this context it is clear that economic and social development will depend essentially on knowledge in its forms, on the production, acquisition and use of knowledge. The move towards the knowledge-based economy has placed human resources in science and technology at the far front of policy debate.

Marginal improvement in education policies will hardly be sufficient. Scientists commonly describe themselves in terms of a single discipline. Fundamental change in working attitude with greater emphasis on transdisciplinarity and multidisciplinary environments highlights the need for a radically different approach to education and training. Interdisciplinary in education and research is becoming more important, but S&T curriculum and training systems are slow to adjust. At the same time interdisciplinarity leads to the emergence of new specialized disciplines, so science and technology policies have to balance, on one side, specialization and, on the other side, interdisciplinary.

Change in the composition of scientific workforce, along with the internationalization of the economy, further advances in technology and the spread of new innovative models of scientific work organization will demand a substantial investment in human capital if the skill and qualification requirement of future jobs are to be met.

In the new models of innovation, scientists and researchers can no longer be trained to work in laboratories isolated from societal and economic prerogatives. Attention should be drawn to the fact that in the future a researcher will not simply be an inventor, but also a communicator who transmits the world's most advanced scientific achievements and thoughts to society.

An apparent lack of interest among young people in scientific research, partly due to insufficient immediate career prospects and overly abstract science teaching, raises concerns about a future shortage of scientists. This explains why one of the major preoccupations of the scientific community in recent decades has been the dwindling numbers of youth opting for S&T which is perceived as remote and inaccessible by a majority of youth in both developed and developing counties. Moreover, it has been presented in manner that is neither attractive, nor relevant to daily life situation. The major challenge was, - and unfortunately continues to be- to make science more attractive and accessible to youth at the same time impressing upon them that it is an integral and essential part of the present and the future.

It is one of the important tasks of science policy to create an environment conducive to good scientific work. For research to become more attractive for young scientists a research climate is necessary that allows for creativity free flows of ideas and talents open communication. Increased exchange of information should strength scientific diversity and draw together potential.

3. The role of UNESCO

The need to promote a world community of scientifically literate and educated was recognized as urgent by the World Conference on Science, organized by UNESCO and ICSU in Budapest, June 1999.

The Conference was an event at which policy makers, scientists and representative of society discussed to the challenges posed by the future of science. The outcome of the **World Conference on Science** was embodied in two principal documents adopted unanimously by all participants, namely the ***Declaration on Science and the Use of Scientific Knowledge*** which underscored political commitment to the scientific endeavour and to the solution of problems at the interface between science and society, and a ***Science Agenda- Framework for Action*** which is an innovative and pragmatic framework for fostering partnership in science and the use of science for development.

The **Declaration** emphasizes that science is a powerful intellectual resource for understanding natural and societal phenomena; that the misapplication of science application of science can be highly detrimental to society, and that science must exclusively serve the cause of peace, that the future of humankind will be more dependent on the equitable production, distribution and use of knowledge than ever; that access to scientific knowledge is part of the right to education, belonging to all men and women, that scientists have a special responsibility for avoiding the adverse applications of scientific research, that the indigenous knowledge has to be recognized and new relationship between science and society has to be established in order to face the today's challenges such as poverty, environmental degradation, food and water security, education.

The Declaration mentions a number of essential principles:

1) **Science for knowledge, knowledge for progress**, which focuses on the crucial role of scientific, research in the acquisition of knowledge, in the education of scientists and education in general;
2) **Science for peace**, addressing the imperative of application of natural and social science for a peaceful world, calling for an 'intellectual and moral solidarity of humankind'
3) **Science for development**, underlining the need for building up an adequate and well-shared scientific and technological capacity trough appropriate education and research programs and the need to strengthen scientific research in higher education and postgraduate programs. It recognizes that technological development needs to be resolutely directed towards less polluting production, greater efficiency in resource use and more environmentally friend products.
4) **Science in society and science for society**, calling for the social responsibility of scientist which implies rigorous quality control of their findings, share their knowledge, communicate with the public and educate the younger generations.

The **Declaration** finally calls on Conference participants to commit themselves to make effort to realize the possibility of promoting dialogue between the scientific community and the society and to act co-operatively within their spheres of responsibility of strengthen scientific culture and its peaceful application throughout the world.

The **Science Agenda- Framework of Action** calls in particular for:
* Changing attitude and approach to the social and environmental dimension of development. Scientists must recognize their ethical and social responsibility to put scientific work in the service of development and peace;
* Improving science education at all levels, formal and informal;
* Adopting interdisciplinary as a common practice will help to break the barrier between the natural and social sciences;
* Creating and promoting the conditions for a dialogue between scientists and society, in order to make science more democratic;
* Reinforcing scientific co-operation.

In thin context UNESCO has thus put a major emphasis on the promotional of formal and non formal integrated interdisciplinary science and technology education with an action-oriented and problem-solving approach for promoting scientific and technological literacy as well as for preparing students for scientific careers.

The thrust of UNESCO's action is placed on:
1. **Training and capacity building**, notably by linking up with regional associated science and technology education training centers/institutions, teachers and relevant NGOs trained in the new approach to STE with a view to develop a reinforced national capacity building in curriculum planning, teacher education.
2. **Exchange of information,** in view of a strengthened networking of schools, science educators and training institution.
3. **Renewal of S&T programmes** resulting in an updated information on the status and recent development in S&T curricula at the level and reformulated national curricula.
4. **Popularization of Science and Technology** for a better public understanding of the bearing of science and technology in every day life, through the creation of links between school-based STE programmes and community initiatives and organization of non formal activities such as contexts, festivals, mobile exhibitions, in collaboration with governments, NGOs, local associations, the media, etc.

4. The International Forum of Young Scientists: vision and project

The International Forum of Young Scientists (IFYS) was held as a satellite event of the World Conference on Science, gathering 150 young scientists from 57 countries (Budapest, 23-24 June 1999). Participants in the Forum discussed general issues and challenges faced by science (science education, science and peace, science for development, equal opportunity, and ethics in science and social responsibility). They discovered that many of the young scientists shared the same concerns as the rest of the community, but also other preoccupations, as outlined in the official statement resulting from the forum.

The Network of these young scientists has been established as a continuous platform in order to make sure that people participate in the follow-up to the Conference and make their contribution in Science Policy design.

In the implementation of the IFYS project priority is given to sensitizing decision-makers and scientific institutions on the necessity to involve young scientists in science and technology policy process, recognizing and introducing the active role of young scientists as agents of change in Science Policies. As science education has to be considered as a science policy issue Academic institutions and educational institutions in general are associated in this action. NGOs of professional young scientists are also partners of the project.

4.1. Objectives

The objectives of the project are the following:

- To promote the involvement of younger generation of scientists in the dialogue between government authorities, parliaments, educational institutions in order to develop national science policies through an open process;
- To increase young scientists' participation in policy and decision-making;
- To improve communication and international co-operation amongst young scientists;
- To involve young scientists in science communication programs;
- To encourage ethical and social awareness and responsibility among young scientists
- To encourage and support interdisciplinary and transdisciplinary projects involving young scientists

The **strategy** is threefold, therefore support is given to the projects 1) **for** young scientists, such as training, fellowships, scholarships; 2) **with** young scientists, involving them as equal partners and focusing on full use of their visions, competencies, experiences and potential in meeting science challenges; 3) designed and implemented **by** young scientists.

4.2. Results expected:

- Consolidation of the International Forum of Young Scientists established during the World Conference on Science
- Raising awareness of policy-makers, educational and scientific institutions on young scientists' concerns and needs
- Effective participation of young scientists in the design of Science policies
- Facilitating the sharing of scientific knowledge and transdisciplinary approach amongst young scientists
- Greater opportunities provided to young scientists to take part in international exchanges

The International Forum by its potentiality and its richens and diversity can be considered a laboratory for the creation of a global community of new generation of scientists. In fact it tries to approach the question of the younger generation of scientists in a broader way, which means combining the specificity of ages and disciplines with transdisciplinarity and intergenerational responsibility. This specificity represents the "added value" of the IFYS, comparing to other youth associations dealing with science issues.

In giving support to the organization of the International Forum of Young Scientists, UNESCO recognizes the commitment of the organization to work not only for young people (which is the case for the most science education programme), but also with them.

This approach is in line with the overall UNESCO strategy concerning Youth. In fact listening to young people and working closely with them in the construction of a peaceful world is one of the UNESCO priorities. At the same time as members of society today (and not only as members of tomorrow's society) young people in general and young scientists in particular have a role to play in defining this new social contract between science and society, which is a common responsibility and as such calls for a multiplicity of visions culminating in collective action.

Young people constitute one of the greatest funds of creativity and adaptability, energy, hope. Day after day young people demonstrate their ability to exploit their own potential and similarly to help to shape and carry out actions for the future. Our action must appeal essentially to young people, to their sense of commitment, and their willingness to mobilize at the global, national and local level.

The commitment of UNESCO with Youth is clear:' Nothing can be achieved without young people, and certainly not behind their backs' it is absolutely essential to involve them in our work, support their plans for the future and assist the search, -by young people and for young people- for innovative solutions'. This mention to innovative solutions recalls me what Paul Berg, Nobel Price in Chemistry in 1980' (and incidentally a participant in the World Conference) said about youth 'Talent s students provide right mix of agitation and skepticism that feeds new ideas and energy to explore them. They are significant source of innovation and in that sense indispensable for research enterprise'.

I would like to mention another initiative undertaken in the process of the preparation of the International Forum of Young Scientists and the World Conference on Science, which was also complementary to them. An electronic forum was launched through an INTERNET based questionnaire in the belief that young people had a role to play in defining the new social contract between science and society that was one of the key themes of the Budapest Conference.

The questionnaire encouraged young people to express their concerns, expectations and take part in formulating proposal for action. The analysis of the results found that young people see science and technology as playing a major role in the type of world, in which they live and would like to see more emphasis given to placing it in a social context. The proposals and recommendations included:

- Ensuring science and technology in school is set in an appropriated social context
- Integrating young people values in the research and development priorities*
- Ensuring governments listen to young people's views in area including science and technology education
- Requiring government to consider developing new ways for young people to contribute to the science policy process

Most young people expressed the awareness of their own responsibility to science and technology development ("There is also the responsibility of youth to where they are heading tomorrow's world".)

5. Conclusions

As regards the growing challenges confronting research and technology in the future, we have to place our commitment in young, talented and committed researchers The consolidation as well as the strengthens of scientific and technological advances depend on their knowledge, their skills and their abilities.

Today's science offers young scientists tremendous opportunities combined with tremendous challenges, but it also raise questions such as: what educational and macro trends concern young scientists? What professional issues arise in this context, what young scientists fell about the future? How do educational institutions at all levels deal with or fail to deal with arising issues?

There is no doubt that the environment in which scientists work is becoming increasingly difficult. Funding has become highly competitive, career post in science is scarce and pressure on heads of research team and young scientists to be productive and publishing with minimal delay are intense.

Sometimes this competitive environment has negative results on the creativity of young scientists. This creativity, which means also scientific risk-taking, is critical to open new avenues of research and bringing about exiting advance. Yet if limited funding and the intense competition for grants cause researchers to seek funding only for 'safe' research instead of research that challenges the status quo, or pushes the boundaries of conventional wisdom, *then* research enterprise as a whole will suffer.

Let me finish this intervention with the Nobel Prize Ilya Prigogine's words on future generation of scientists: "We are only at the beginning of science and far form the time when it was believed that one could describe the universe in terms of a fundamental law. It is up to future generation to build a new science that incorporates all these aspects, for at the moment science is still in its infancy. It is up to future generations to construct a new coherence that will incorporate both human values and science".

I think that our commitment is to create the best conditions for young scientists to make it possible. It is my whish that the International Forum of Young Scientists' initiative can contribute to achieve it.

References

[1] [1] UNESCO-ICSU World Conference on Science (Budapest, June 1999) http://www.unesco.org/science/wcs/index.htm

[2] [2] International Forum of Young Scientists (Budapest, June 1999) http://www.unesco.org/science/wcs/youth/young.htm

The Impact of Public Policy and Private Initiative in Promoting Gifted and/or Talented People

Mihai JIGĂU
Institute of Educational Sciences,
37 Stirbei Voda Street, 70732 Bucharest, Romania

Abstract. In the following are presented the principal issues of public policy and private initiatives oriented through differential upholding of gifted and/or talented children in Romania after the 90`. There are also underlined some of the legal provisions that settle and facilitate the upholding of the gifted and/or talented children and also the representative institutions acting in this area.

1. Introduction

The explicit and differential upholding of children intellectually gifted and/or talented (CIG/T) and also the acceptance of the educational and social responsibility for this phenomenon is a process with ups and downs, connected with the politic, economic and cultural context. It is still believed that a CIG/T child, because of his/her gift, will succeed in personal, professional or social plan. In this case, it is considered that supplementary resources investment in his/her education and formation is not a necessity or a priority, as long as other aspects such as the handicapped children are not solved.

This opposition is totally unjustified. It is not a matter of ignoring one category because of the other, but assuring the maximum personal development of each of them, depending of resources, which means putting into practice an educative objective, that of "equality of chances in education", and implicitly ensuring "the right to diversity". Generally speaking, society encourages and develops emotionally acts systems that have a role in creating a generally presumed equalitarianism, as a noble intention, but unreal concerning the biological reality, for satisfying the people need for uniformity and "known" (as a type of neo-phobic reaction).

To conclude, the problem of gifted children in Romania is also under the impact of great share of prejudices, reluctances and contradictory attitudes. The arguments are from different sciences: pedagogy, psychology, politics, ethics, moral or psychoanalytical domain, generated by inconsisent defenses, fantastical projections and unjustified anxieties.

The political changes occurred after the 90` in Romania and the beginning of an ample process of educational reform at all levels have been good occasions to improve the educational aspects of CIG/T.

The Romanian economic difficulties - impossible to anticipate for this type of transition – and the deficit of "positive image" in the external plan have generated social frustrations in different sectors connected with the educational domain, materialized in increasing the social acceptance for investments and preoccupations for CIG/T.

It must be admitted that, many foundations and associations which intend to uphold CIG/T, are rather sources for searching donors, founds, and financial resources for upholding and rewarding CIG/T already confirmed (with successes in national and international competitions in scholar disciplines) than initiators for CIG/T training programmes. Long-term investments for probable future results are not sufficient rewards for "donors and found-raisers".

On the other hand, the authorities use the CIG/T success as an "argument" for the general quality of the educational system and for the reforms in the educational area. This is not generally applied in all cases. First priority is the immediate, visible, present aspect.

In the social quotidian plan, the little and very little CIG/T children capable of exceptional results (figure memorising, rapid mathematical calculations, musical and hearing memory) are "made famous" by mass-media (especially TV). But many of them are rapidly forgotten after various TV stations "exploits" their impact on the audience and parents aspirations.

It is a necessity, in this moment to create some parents associative bodies to lobby for CIG/T children towards the political authorities, civil society or responsible institutions in the field. After the 90`, an educational policy oriented towards children with high scholar performances-CIG/T, was not explicitly the object of systematic preoccupations, supported by a legal system. Nevertheless, there cannot be ignored some educational policies and legal documents elaborated by the Ministry of Education and which, even if they are not referring only to this category of pupils, have had an impact on our subject of interest.

The openness and/or relaxation in social and legislation field after the 90` created new opportunities for initiatives focused on education and training for gifted and/or talented children. At the pressure of the social climate, the teachers have begun to undertake new tasks, others than the pedagogical ones. At the same time, they become the organisers for extracurricular/ extra-scholar activities, for counseling and career counseling services for gifted and/or talented children and for their communitarian upholding. Will all these, a real educational policy initiative is not overlapping, nor it can be associated with the educational reform.

The idea that performance and creativity in different areas of human expression are absolutely necessary for any society aspiring to social equitability, cultural and scientific performances and economic prosperity is not really assumed yet; in this perspective, the upholding and non-discriminatory stimulation of any form of higher human potentially becomes a condition for development and a positive attitude towards these children.

Unfortunately, in many cases, the gift is associated only with higher intelligence and/or higher academically knowledge; time has to pass to admit the concept of high intellectual potential or success in different domains, among which the academic performances represents only one possibility. We cannot be sure that a child with brilliant scholar performances is or not a gifted child and that he will "conserve" or not this performance, materialising it in professional, social and/or artistic success, in a favourable environment and with a strong social request.

On the other hand, the practitioners consider that the performances reach a "level" which children cannot overcome through new investments in material and technologic resources; it has to be activated the strategies which involve the motivational, affective and interest level (more and more personalised).

2. Public policy

The official legal regulations that can be used in favour of the intellectually gifted and/or talented children are to be found in the Education Law nr. 84/1995, where stated:

Art. 3 (point 2) Free, full and harmonious development of the individual, of one's independent and creative personality is the educational ideal of the Romanian school.

Art. 5 (point 2) The state promotes democratic education principles and guarantees the right to differential education on the basis of educational pluralism.

Art. 7 (point 6) The state sustains financially the schoolchildren and students with outstanding achievements and which prove special abilities in a certain professional area. (point 7) The state and other factors concerned subsidise student high-performance activities of national and international level.

Art. 10 (point 4) The Ministry of Education may approve the creation of education units or classes of outstanding students.

Art. 16 (point 2) Outstanding students with very good school record can take two forms in one academic year.

Art. 24 (point 2) Secondary schools can train in one or more fields. Within a field, narrow specialization classes can be set up, as well as special classes for outstanding students, but they are subject to the Ministry of Education's approval.

Art. 37 (point 1) Instruction in art and instruction in sport are organised for students with special aptitudes in the respective fields.

Art. 40 (point 1) For competitive sport and professional art activities, the Ministry of Education can set up school clubs, schools and secondary schools with sports or art classes on an integrated or complementary basis.(point 2) The Ministry of Education, in the support of professional artistic and competitive sport activities, can set up sports or art camps; arrange sports or art contests, school championships, festivals; and grant scholarships and other support. (point 3) The Ministry of Youth and Sports, the Ministry of Culture and other concerned ministries are under the obligation of providing financial and material support to competitive sports and high-performance artistic activities.

Art. 59 (point 2) Secondary school graduates who won awards at continental or international school contests, world or Olympic arts or sports competitions during the last two years preceding graduation, can enroll in a faculty or stream of study without having to take an entrance examination. (point 3) High school graduates, baccalaureate diploma holders, having obtained awards at school subjects competitions, art or sport national or nation-group contests in at least one from the last two years of study can be admitted to higher education according to the general criteria established by the Ministry of Education and to the specific criteria elaborated by the university senate.

Art. 141 (point k) The Ministry of Education ensures identification and corresponding preparation of students with special abilities.

Art. 175 (point 1) The extracurricular activities - scientific, technical, cultural, artistic and sports, as well as those designed for outstanding students, are financed from the state budget, according to the regulations established by the Ministry of Education. In this purpose, there are other financing sources that can also be used.

As a general note, it can be observed that the new Education Law is open to education and training of intellectually gifted and/or talented children and shows responsibility to the young generation that has the potential for becoming competitive. Nevertheless, the issue of intellectually gifted and/or talented children does not represent the concern of a distinct chapter of the law; the focus is solely on the formal education system, by ignoring the non-formal and informal system. The references to the discussed subject can be found among articles and points setting other issues.

Within the same framework, we shall mention a set of ministerial regulations, which provide supplementary provisions and enlarge the field of educational preoccupation in the favour of intellectually gifted and/or talented children.

Education minister's Ordain no. 3052 from 9th of January 1998, regarding *How to reward the students with special achievements*. According to this, in the higher education institution there are to be introduced merit scholarships, granted on a competitive basis, for duration of 12 months, by each institution itself, to its most outstanding students in the academic, research and innovative fields.

Education minister' Ordain no. 3138 from 19th of January 1998 regarding the *Stimulation and valorisation of the outstanding young students*. According to this, the outstanding young students in. the academic field are to be supported by the universities and legal authorities, with material and financial facilities. Moreover, there is under discussion the opportunity of introduced achievement scholarships for high school and tertiary students and scientific excellency grant for university teachers.

Education minister' Ordain no. 3373 from 10th of March 1998 regarding the *Establishment of Centres for Scientific Excellency within the universities*. These are conceived and act like organised research bases, having competitive research programs as core and including teachers, researchers, Ph.D., M.A. students or other outstanding young people in the field of scientific research. The centres are financed by budgetary allotment.

Education minister' Ordain no. 3419 from 16th of March 1998 regarding the *Enrolment in the secondary education of the graduates having obtained awards in national and international school competitions*. According to this, the high school graduates having obtained 1st, 2nd or 3rd award, respectively gold, silver and bronze medals in national and international subject competitions, artistic or sport contests in at least one of the last years of study, have priority for enrolment in higher education beyond the number of places available to those faculties or streams of study corresponsive to the subjects they were awarded in.

Education minister' Ordain no. 3697 from 12th of May 1998 regarding the *Regulation of the school situation for professional sport students*. According to it, there are granted some facilities for professional sport students regarding their attendance to courses, postponing examinations, final closing of school situation, extending the duration of education, transferring to other institutions etc. All these provisions aim to facilitate the participation to the training stages and sport competitions of the students from national or international sport teams.

Education minister' Ordain no. 3951 from 7th of June 1998 regarding the *Regulation of activities related to the admission into higher education of high school graduates having obtained international sport awards*. According to it, the sportsmen that are high school graduates and winners of the 1st, 2nd or 3rd award in the Olympic games, have priority for enrolment in university type education, without sitting for an admission competition. Winners of the 4th, 5th or 6th award in the Olympic games, World championships or European championships (seniors, youth, juniors) or components of the national teams qualified for the Olympic, World or European final tournaments can, also, enroll without taking an entrance competition, but on the condition of a favourable university senate' decision.

Education minister' Ordain no. 4400 from 30.08.2000 regarding the *Criteria of organising and running the admission in the state higher education in 2001*. A special chapter of this Ordain deals with the enrolment of Olympic pupils. It is stated here that the candidates with recognised performances in the international competitions have the right to subscribe in the higher education system without taking the admission exam, according to the number of places allotted by the Ministry of Education and Research. This category includes the candidates with distinctions at the national or international subject competitions and at the international artistic contests or medals for the 1st, 2nd or 3rd places at the Olympics, World or European Championships (seniors, youth, juniors).

3. Centre of Excellency for Outstanding Students (CEOS)

One of the most relevant public institutions in this field is the *Centre of Excellency for Outstanding Students (CEOS)*, established in 2001 by the Ministry of Education and Research.

In the beginning of the Ordain is stated that «The students able of performances must be seen as a national asset, having special instructional needs during the school" and that „...the passion and the preoccupations of the students able of high performances must be appreciated and respected by the society..."

The basic assumption behind this assessment is that: „there is a acute need of establishing a body that would give these students a proper qualified assistance, more adequate to their aptitudes and needs of instruction and that will promote methodologies and instruments for identifying the authentic value and for developing their specific creativity".

This organisational structure operates at all levels of the educational and training system in Romania.

The main activities undertaken by these centres are:

- identifying the outstanding students by using scientific and psycho-attitudinal criteria;
- developing strategies and the programs of instruction in cooperation with specialists on different subjects;
- monitoring the evolution of the outstanding students on a period of 15 years starting from the moment of identification;
- supporting the higher education institutions ready to develop and implement programs of instruction for students with high performances;
- establishing relations of cooperation with institutions able to support scientifically, psycho-pedagogically and logistically the instruction of these students;
- offering recompenses to the students and to the teachers involved in their training;
- according Diplomas of Excellency for students following the training programs and obtaining outstanding results.

The performance education activities are usually held in the weekends (Saturdays), in the weeks before the holidays, as well as in the summer holiday.

The Department for psycho-pedagogical strategies of the Centre, using scientific and psycho-pedagogical criteria, will do the selection of the students with special aptitudes. The students holding Diplomas of Excellency can obtain, during their university studies, contractual scholarships from the *CEOS* in cooperation with the higher education institutions in which they are enrolled and where their educational performances are promoted.

The teachers working with this category of students are usually selected from those proving a regular interest toward the performance training of the pupils and show didactical skills compatible with the nature of activities designed for students with this potential for performances.

CEOS constantly establishes and updates the rewards for the outstanding results obtained, both for pupils and for the teachers. These include:

- scholarships in the country and abroad;
- study and rest camps;
- study excursions in the country and abroad;
- participation at symposiums and conferences in the country and abroad;
- financial rewards;
- rewards in books, objects / useful instruments in the school study.

The Ministry of National Education and Research has nine such Regional Centres, organised on groups of neighbouring counties.

Nevertheless, the permissive legislation does not induce automatically the amelioration of the school performances that can be obtained in the education and training of the CIG/T. Other important factors are: the professionalism of the teachers, the positive attitudes of the community towards the education of the CIG/T, the material basis, the curricular design proposed, the theoretical-scientific developments of the field, minimisation of the social stereotypes towards this minority etc.

The economic and political similarities of the Central and Eastern European Countries created equivalent models of preoccupations toward the stimulation of the CIG/T, as following: school subject competitions (local, regional, national, international), special classes (of math, physics, biology, informatics etc.) or of material / social support by scholarships for those with high school performances. Nevertheless, the common issue was the equivalent treatment of the pupils, deliberately ignoring the individual differences given by the biological and socio-cultural ambient factors.

The amplitude of the phenomenon of school subject competitions can be assessed through the statistical data regarding the schools year 1999-2000: 70 of contests and school subject competitions, with a number of participants of 8891 pupils, 1844 accompanying teachers and 1117 teachers in the assessment commissions.

Merit and study scholarships are in Romania forms of positive sanctions of pupils with outstanding academic results (from all levels of the educational system) and they are granted during the schools courses, including the training time and the baccalaureate or diploma examinations as well as during the practical training periods. There are also important the special extracurricular and non-formal activities for CIG/T pupils during the vacations, the creation camps, applied research stages in certain fields, as part of various state or NGO's financed projects.

4. Private initiatives

RO-Talent *"National Association for Gifted and Talented Children and Teenagers"* (Iasi) is a "non-governmental organization aiming to provide psycho-pedagogical assistance to gifted and talented pupils, on specialty areas, as well as to their trainers, parents and teaching staff".

The general objectives of the Association are:

- informing the parents, the decision makers and the whole community about:
- CIG/T characteristics and
- Special learning needs;
- pleading for the creation of a legal framework for facilitating their education, training and socio-professional insertion in a stimulating manner and the development of a favourable climate to initiatives in the field;
- training the teachers working with gifted and talented pupils, as well as their parents;
- promoting their rights in the social sphere and towards the national and European bodies.

The specific types of activities organized by the Association are: counselling, seminaries, conferences, competitions, symposiums, workshops, clubs and summer camps, extra-school activities etc. RO-Talent is active member of EUROTALENT starting with 1992 and is collaborating with UNESCO, UNICEF, Council of Europe, ECHA and other educational institutions at the national level.

The *"Henri Coanda" National Foundation for the Support of Gifted Young People,* people who became visible through their results in competitions on different subjects, both nationally and internationally. The Foundation aims to:

- sustaining, materially and morally, gifted young people who obtained remarkable results in contest on various school subjects;
- stimulating knowledge activities through specific extra-curricular activities organized for gifted students (subject clubs, study and creativity camps, financial and material rewards, scholarships abroad);
- supporting research in the field, training of the teaching staff working with these pupils, national and international collaboration with recognized specialists, organization of scientific reunions etc.

The *EXCELSIOR Foundation* was created in the view of supporting materially the children and young people gifted and talented in different academic and artistic domains. Also, the Foundation organises special artistic activities performed by young artists (piano and violin players etc.), exhibitions of the young painters etc. The Foundation is supported by acknowledged Romanian personalities in arts and science.

There are, no doubt, other foundations and associations with similar activities all over the country but they are unknown to us, for the moment. The main objections one would bring, traditionally, to most of these educational initiatives in the field are related to the viability of the identification/selection methods, the costs and design of the proposed curriculum for CIG/T included in special programs (classes) of accelerated instruction or in intense study stages.

5. Projects

There are other projects and initiative worth mentioning, even though they are not fully developed. One of those is the *Centre for Differential/Complementary Instruction,* which aims to contribute to the realization of a more flexible educational offer for the children with high intellectual capacities, with recognized talent in various artistic fields or children who want to discover their possibilities and value them through supplementary education.

The Centre was established with the scope of creating an organized framework able to provide the professional, logistic and educational support at the level imposed by the intellectual capacities, the talents or children's desire for additional training. The selection and complementary instruction of pupils will be made during the compulsory education and the programs will be organised in modules of accelerate learning, of enriching their knowledge etc. The Centre will be able to develop research, guidance, psycho-pedagogical monitoring and professional training modules.

The objectives of the Centre for Differential Instructions aim at:

- creating educational facilities for children with medium and/or superior level performances;
- providing the conditions and adoption procedures of a flexible program, adequate to gifted children, for the entire education period;
- permanent evaluation of results by experts appointed by the Ministry of Education, specialized in Pedagogy, Psychology and the subjects of performance, through comparison with test groups;
- selecting the teachers according to their intellectual and professional capacities, their aptitudes, personality and availability for continuous training;
- selecting the students according to their aptitudes, intellectual level, personality traits;
- developing specific curricula;
- identifying optimal strategies for different categories of intellectually gifted or uncommon situations;
- offering programs that will allow accelerate instruction or other specific forms of instruction.

Another initiative - still in the project stage but following to be soon implemented – refers to the *Organizing and functioning methodology of the education units, classes and groups of differential education for gifted pupils.* Within the same frameworks are also proposed regulations for the "jump" of a study form by gifted pupils. Through this methodology are brought clarifications, modifications and adaptations on the following aspects of the education process: goals and objectives; curriculum content; instruction strategies; organizing and grouping the students; human resources; evaluation strategies; connections with the non-formal education institutions; school adjacent services. The afore-mentioned activities will be organized as follows: daily; weekly; only on Saturdays and/or Sundays; all through the school year; during school holidays; yearlong.

The motivation for creating education units, classes or education groups for differential educations resides in the acknowledgement that any democratic society should offer equal chances for full personal development to all children, including the gifted and/or talented ones. The creation of such centre, dedicated to CIG/T represents a way of obtaining social "credit" for those intellectual potentialities capable of superior performances.

Democracy means not only the right to education in its understanding as an act of culture, but the basic right of everyone – and the society has the moral obligation to provide education for everybody- for having the real possibility of maximum utilisation and valuing of the natural potential, meaning, in fact, guaranteeing the "right to be different".

From Jefferson to Feynman: U.S. Aspirations for Science and Technology Education

Rodney W. NICHOLS
President and CEO, New York Academy of Sciences [1992-2001]
rod.nichols@verizon.net

Abstract. U.S. middle and secondary schools have not performed well in science, technology and mathematics. Jefferson set high aspirations, made a longstanding commitment to public education, and emphasized the sciences. Feynman epitomized American distinction in discovery and saw the increasing need for training in science and math to fuel economic growth. But the U.S. has failed to fulfill these aspirations. Although a few schools excel, standards have dropped and reforms have failed over many decades. While public support for research is strong, public understanding of science is weak. Highlights of trends reveal deeply entrenched problems. Paths for constructive change are in view.

1. Summary

Few issues in America today evoke as much passion as the choices for how best to improve education in the schools. Failures in science and math are striking symptoms of the lackluster performance of most U.S. middle and high school students.

I survey this tangled subject from the perspectives of an applied physicist, a science and technology policy analyst, and a concerned citizen. Although I have tutored gifted students, volunteered as Principal-for-a-Day in New York City schools, served on college and university boards, and managed student-oriented programs at the New York Academy of Sciences, I have never had full-time responsibility in science education. My views relate to what the NATO workshop co-chairs characterize as the "social environment."

The challenges for science education nest in the gridlock about how to achieve the larger goals for U.S. secondary schools. In this survey I mainly probe the larger themes. Only by understanding the prevailing traditions, constraints, and values—and only by breaking out of the boxes they create—is there a chance to reverse discouraging trends. Some key problems and attitudes in the U.S. appear to be absent elsewhere in the world. But many appear to be similar in all developed countries.

I begin with the ideas of two American leaders, Thomas Jefferson and Richard Feynman. Their insights illuminate essential goals.

Jefferson's erudition, inventiveness, and curiosity informed his lifelong commitment to public education at all levels. He knew quality education was the bedrock for sustaining effective democracy. Feynman's extraordinary talent in physics was matched by a restless interest in almost everything. In a little-known anecdote found in his light-hearted autobiography, he revealed his epiphany that advancing knowledge is the indispensable basis of effective economic development.

Those objectives still stand tall: prepare all citizens for self-government, and develop the human capital for economic progress. In the 21st century, education in science, math, and technology must be priorities for education everywhere.

2. Jefferson on Public Education

For Jefferson, dedication to excellence in education was fused with respect for originality in scientific discovery. He "gladly made himself an heir" (of the Enlightenment) and counted "Sir Isaac Newton and John Locke...with Lord Bacon in his trinity of immortals" (1). The American people admire Jefferson "as the chief prophet of public education" (2) because he said "Preach...a crusade against ignorance; establish and improve the law for educating the common people" (3) He emphasized education's overarching goals: "to guard the freedom and happiness of individual members of society"...(and) "to assure wise and honest government" (4).

In his thinking about curricula, he explicitly emphasized "higher branches" of mathematics and "all the useful sciences" (5). His encyclopedic *Notes on Virginia*—Jefferson's only book, a pioneering effort in natural history--was respected by professional scientists in Europe. Moreover, his life-long habits of empirical observation systematically touched dozens of subjects from climate and winemaking to astronomy. His inventions remain the marvel of all who read of his indefatigable activity in designing devices such as an autopen. A founder of the Library of Congress with the gift of his library, he later devoted the final years of his life to creating the University of Virginia. That extraordinary institution glows brightly two centuries later with his architectural and intellectual inspiration. Jefferson's spirit for the university's, and the nation's, goals may be understood by reading his words over the entrance to Cabell Hall: "For here we are not afraid to follow truth wherever it may lead, nor to tolerate any error so long as reason is left free to combat it." (T.J. letter to William Roscoe, 1820)

In creating the rich U.S. tradition to extend public education, Jefferson favored decentralized governance, offered "consistent support for religious freedom," and laid "greatest emphasis on the elementary stage of education" while seeking "academic excellence" (6). Most Americans hold these values. Today, however, the institutional performance in K-12 education—particularly in math and science—does not measure up to Jefferson's standards. So the success of his vision of democracy is in jeopardy.

3. Feynman on Economic Development

All young physicists know—usually, they are intimidated by—the spectacular talent of Richard Feynman. His crystal clear lectures, his intuitive sense of the fundamental, his unquenchable determination to crack problems, theoretical and practical—all set him apart. He brought powerful analytical ability—and human zest—to everything he did.

So perhaps it should not have been a surprise to me that he took only a few days to see—and tag in plain language—a point about the source of global economic disparities that too many ignore. His insight is a bracing reminder about why science and math education are crucial for every 21st century knowledge-dependent society. Here is the story.

In the early 1950s Feynman attended a conference on "the ethics of equality." As he tried to digest the opening sessions, he said he did not "understand what the problem *exactly* is" (7) [italics in original]. At one point a theologian argued—passionately, according to Feynman—that rich countries such as the United States should share—i.e., give up—everything they have with poorer countries until "we are all even." As "everybody was listening to this," says Feynman, "we were all full of sacrificial feelings and all thinking we ought to do this. But I came back to my senses on the way home" (8). Feynman saw that "the idea of distributing everything evenly is based on a *theory* that there's only X amount of stuff in the world...but the *real* reason for the differences between countries...isn't the *stuff*, but the power to *make* the stuff" (9) [Italics in original]. His fellow conferees—from history, religion, law, philosophy—"were not in science (and) didn't understand technology...they didn't understand their time" (10).

Feynman's epiphany pierces fogs of mushy rhetoric about well-meaning plans for economic development across the globe. Although the effort to increase standards of living is complex in the best of circumstances, it indisputably requires that a growing proportion of people become literate and numerate. A nation must learn how to "make the stuff." While economists persuasively show there is no need to make everything—trade has compelling advantages—rising local expertise remains essential. One powerful example of the dynamics of education as an engine of modernization is Taiwan's past generation of progress. K. T. Li documents convincingly that public-private partnerships in technological education were central to Taiwan's success (10a).

Every nation must pay attention to these fundamentals. Each citizen in a democracy needs a broad education to manage self-government, as Jefferson urged. Each individual needs a base of mathematical and scientific skills to thrive in the modern economy, as Feynman saw.

4. Supplementary Programs in New York City

Let us turn now to an illustration of the practical questions that must be answered to achieve a nation's diverse social and economic objectives. For all developed countries the secondary school classrooms are a critical domain. And this is increasingly important for developing countries that wish to accelerate their modernization. Especially when a school's science and math components are inadequate, supplementary programs can help nurture the development of students. New York City has many such efforts to compensate for the crippling flaws in its formal system. One illustration of supplementary programs is summer internships. A second example is science fairs.

Summer Internships. More than 300 universities and research institutions in the U.S. offer science and technology internships for high school students (11). For the past two decades, the New York Academy of Sciences has conducted such a program for eight weeks each summer. Students are selected through a competitive process. Each applicant is interviewed to understand the individual's maturity and interests; this process is time-consuming for the staff, but it is a revealing step. Scholarships are available for those who cannot afford the tuition. The program is oriented to the cohort of students who are inclined toward science, but not necessarily to the most gifted. After acceptance, each intern is matched with a mentor active in the field of the intern's goals. The purposes are to enable students to learn about day-to-day life in actual laboratories—within a governmental, corporate, or academic setting—and to participate as a junior associate in a professional effort.

To improve understanding of the impacts of this program, in 2000 the Academy conducted an evaluation of the 555 students who had participated during the summers of 1994-1999. About one-third of the students responded to the survey. Between 50% and 75% of the respondents reported that the internship experience influenced their choice of career and college. More than 80% said they learned about the research process, having known nothing about it before. Taking account of the high enthusiasm of the interns during the summer, and relying upon anecdotal information to supplement the survey, the overwhelmingly clear conclusion was that many students found that the internship strengthened or created their conviction to go on to a career in science. This activity is a success and can be replicated anywhere mentors are prepared to volunteer.

In truth, however, too little is known on a rigorous basis about what to call "success" (or "failure") in these internships. No doubt every student absorbed an enriched education outside the feeble science programs in most New York City schools. Furthermore, two-thirds of the Academy's interns majored in science in college. But no controlled studies have been conducted to learn how much these results reflect self-selection by those who already had decided to enter university education in science.

What is clear is that virtually all interns—about 80%—value the experience. They learn many transferable technical skills, they practice writing and presentation, they begin to understand the nature of a research environment, they sense what it means to a scientist (12). As a result the students can assume jobs in technologically sophisticated enterprises. Moreover, the internships equip students with a broad capacity to assess major choices facing the electorate, such as the risks and benefits in nuclear power or the pros and cons of xenotransplantation.

Science Fairs. A second type of supplementary program outside schools is the science fair. It is an open, competitive activity in which high school students prepare independent projects for review by professional judges. Many comparable events have been held throughout the U.S.

The New York Academy of Sciences has managed for more than thirty years what is now called a "Science and Technology Expo." The New York Academy Expo sends its winners to contend in the Intel International Science and Engineering Fair, involving students from many countries. All participants in the N.Y. Expo receive visible recognition; this minimizes the divisive, possibly demoralizing features of a contest that does, in fact, set high standards and conclude with winners. These events heighten public awareness of science, enforce yardsticks for intellectual quality, show students' talents, and underscore the importance of encouraging teachers and parents to help students follow their curiosity by taking concrete initiatives. A "Rube Goldberg" category attracts students (often in small teams) who love "tinkering with gadgetry."

During recent years, the number of New York S. & T. Expo participants rose rapidly, increasing from about 500 in the mid-1990s to almost 900 in 2002. The reasons for the growth are not well understood. One explanation is that more advertising and publicity stimulated more students to enter. But newspapers, sad to say, pay little attention to the good news about the extraordinary preparations of hard-working students. Another possible explanation for the added participants is that students have been responding to increased public attention on information technology, cloning, smart bombs, space telescopes, and other technical advances in the news every day. Further stimuli include the forecasts of growing jobs in science-related fields and the awareness of competitive advantages for students who show extracurricular activity in an Expo on their applications to college. No one of these conjectures is entirely persuasive. In any case, controlled assessments are not available.

Whatever the speculations about the long-range benefits of an Expo, the event always is exciting for the participants (and for their parents and siblings). The students are enthusiastic, proud of their accomplishments, eager to learn more from judges about their chosen subject, and often decide to extend their initial work for another year in a more complex project. These features of the event's immediate impact generally produce pressures on schools and science/math teachers to facilitate broader student participation in subsequent years. In a more subtle sense, the Expo lifts the veil that masks the mediocrity of most schools' science programs. The Expo encourages every interested student, not just the gifted, to be creative and go beyond bookish routines. Conducting an Expo enables all schools—and all families—to see what is possible when students develop their own ideas with only a modicum of guidance. As an irritant to the establishment's declared doctrine on what science is and how it is taught, the "science fair" concept becomes a catalyst for raising standards, freeing up the guarded expectations for students, and opening opportunities for turning curiosity into learning.

Profound Benefit. A powerful benefit flowing from both internships and science fairs is their capacity to arouse in students a sense of the fun and the beauty, the predictability, as well as the surprise, and the satisfactions as well as the frustrations of authentic inquiry.

To illustrate the point, consider *Uncle Tungsten,* Oliver Sacks' sparkling new memoir of his childhood. Sacks says he learned about "deep practical knowledge...long before theory" ...the "exciting change," for instance, that occurred when tungstic oxide was heated with carbon in a furnace (13). As Sacks began to understand more, he came to see that "the history of science was anything but a straight and logical series, that it leapt about, split, converged, diverged, took off at tangents, repeated itself, got into jams and corners" (14).

Such authenticity about the real-world discovery-process rarely appears in textbooks. Even if it did, the point is that Sacks's curiosity was nurtured by doing science, not by memorizing facts for quizzes. He trudged around the lab, sampled museums, surprised himself with what he could learn, and saw what more he needed to know. All students benefit from this participative approach. The idea is to "see for yourself," in the historic words of the British Royal Society's revolutionary motto.

But hands-on fun is almost nowhere to be found these days in school. Most classes are too large for time to be devoted to guiding individualized study. Few teachers possess the mastery, flexibility, and verve to orchestrate an inquiry-based approach. Laboratory facilities are not available or poorly maintained. Budgets are too tight to allow continuing purchase of expendable materials. A sad state of affairs.

So Oliver Sacks was fortunate. His family—both parents were physicians—created a stimulating environment with equipment and encouragement. Few students are so lucky.

For most students, supplementary mechanisms must be added to serve as the surrogates for Sacks' family. That is the strong justification for inviting academies, universities, hospitals, and firms to assist the formal school system with extracurricular programs such as science internships and fairs. They make a difference.

5. Organizational Hurdles for Local Programs

Despite the benefits of these enrichment programs, however, many hurdles loom for the local groups managing them.

Scale. In New York, one hurdle is the sheer scale of the system. With 1.1 million students and 60,000 teachers in the City's K-12 schools, the Academy's programs reach less than 0.01% of the presumably eligible students and teachers. Given this narrow reach—while acknowledging high impact for those few involved—sponsors often wonder whether their support is a drop in the bucket. The question of scaling up is a chronic frustration. With more resources, would more students participate? Probably yes. Would criteria for participation have to change? No one knows. Would the benefits be worth the costs? No one knows.

Funding. A related hurdle is the quest for funds to sustain the programs. When new ideas compete for scarce resources, any continuing efforts seem merely a routine. No matter that each year fresh students are engaged as interns or Expo entrants; for them, the program is "new." Many private donors in the U.S. have explicit policies prohibiting long-term funding of a continuing program. Government agencies also have difficulties in sustaining long-term projects, especially those that hint at inadequacies in fulfilling their core tasks. The New York City Board of Education regularly kept the New York Academy on edge about financial support; and the Board never paid its bills on time!

Turnover of Volunteers. Another example of the day-to-day frustrations of organizations administering internships and fairs is the inevitable demand for replacements to make up for the turnover among mentors and judges.

The mentor of a high school summer intern must make a considerable commitment of time. Patient tutoring and responsible guidance cannot be done on the fly or on the cheap. Issues of liability for accidents, or other mishaps, also give pause. Although many scientists and engineers are gifted in mentoring—and take great satisfaction in it—today professionals are busy, concerned with their own research and funding, pressed by their firm's or university's goals and deadlines. Furthermore, sometimes it is difficult to match each intern with an appropriate, dedicated person in the student's specific field of interest.

The S&T Expo needs qualified teachers or volunteer scientists to guide a student's independent project over many months. Then the Expo event itself needs a large panel of judges who possess a constructive temperament and the robust knowledge sufficient to evaluate hundreds of projects with fair, wise critiques. The pool of individuals who will assume these responsibilities is never large and must be replenished regularly.

Cooperation with Establishment. A non-profit staff also faces hurdles in working with the teachers and administrators inside the school system. For instance, even if supplementing the formal curriculum has been declared officially as an objective of a school—and it often is—that dedication usually is rhetorical flourish.. The "system" is usually bureaucratic, slow-moving, disinclined to give (much less reward) autonomy to the teachers who possess the vision to encourage students to move beyond minimal requirements. Worse still, the established system rarely replicates any positive lessons learned by one school or in one program. It is almost impossible (in New York City at least) to be "systemic" in reform, i.e. to diffuse effective improvements across the entire system. One reason for this is that principals, overwhelmed in every large city with administrative and political burdens, frequently do not rank science and math as high priorities when their students' reading and writing scores are also poor. The resistance to change within the system reinforces the resistance to adopt innovation available outside the system.

Politics of Governance. In New York City the governance of schools is hotly contentious. Power over schools and their budgets is the core of disputes in most American urban areas. Former Mayor Giuliani and the recently elected Mayor Bloomberg have argued that the mayor, rather than a politicized committee called the Board of Education, should appoint the chancellor of the city's schools. It is a strong argument. What was once seen as progressive reform—making the Education Board a professional and independent body immune to the whims of elected officials—is now seen as the main source of growing inflexibility, severe lack of accountability, and stiflingly narrow vision. What was once seen as "power to the people"—a Jeffersonian-style, decentralized governance at the grass-roots level—is now seen as naïve confidence in invisible amateurs. Mayor Bloomberg said, "If democracy can be trusted to provide us with public safety, social services, and economic development, how can we responsibly condemn our children to something less?" (*New York Times*, 2 March 2002, p. B3). He is willing to take the heat if schools do not improve.

The first radical reversal in thirty years, change to mayoral control—finally authorized in June 2002 by the New York State legislature—clarifies in stark fashion exactly who is responsible for science and math in the schools as well as who can orchestrate productive partnerships with external groups for projects such as internships. For this new experiment in governance, New York will begin to insist on new standards, reliable data, and professional management. Former Deputy Mayor Anthony Coles calls for a new "Schoolstat" program to evaluate schools, principals and superintendents. (*City Journal*, Summer 2002, p. 51) Change will be slow.

Evaluations. A general national hurdle for assembling evidence on how to reform science education is that evaluations are often sketchy. Despite valiant efforts by a few analysts, the education literature is neither as quantitative nor as science-oriented as the best professional science-educators would prefer. Much more credible research is needed.

At the 2002 Annual Meeting of the AAAS, held last February in Boston, physicist and teacher-training advocate Leon Lederman organized several sessions devoted to "seamless K-16 science education." The sessions spanned such tasks as upgrading curricula, sharpening student assessment, and accelerating programs for the professional development of teachers. Meeting these overarching challenges for the nation's schools will demand crisp plans built upon a firm base of data and subjected to continuous evaluation. For instance, as I noted earlier, should internships and other enrichment projects expand? Are such supplementary projects relevant to the "core performance" of schools in science and math? What combination of factors leads to better overall performance? Probing investigation is essential.

But educational research efforts are still so small in relation to total U.S. R&D that the amounts rarely qualify for inclusion in summary national tables. The annual investment in the Federal Department of Education's R&D for Fiscal Years 2000 and 2001 was about $265 million. That is a puny pledge within the nation's trillion dollar educational establishment, and it was less than 8% of the total budget of the National Science Foundation. The NSF alone aims to spend $200 million in FY2003 for a new math and science partnership focused on K-12 education within a total request of $908 million for education and human resources (14a).

Recently, incendiary political controversy ensued after the release of test scores in New York showing that black and Hispanic students lag far behind whites. To be sure, some data are fuzzy and some national and state-wide tests are poorly formulated or outdated (14b). But if the U.S. had been as serious about educational improvement as it has been about biomedical research, more penetrating diagnoses and more effective therapies would have been developed.

Within the larger American research community, rigorous study of educational efforts continues to be a stepchild. Most scholarly talent goes elsewhere. Within American universities, the schools of education have been unbridgeably alienated from faculties of arts and sciences. Teachers-in-training learn little about science and technology.

These hurdles in evaluating education exist in most countries. Enhanced global exchanges such as this NATO Workshop can build sturdier foundations for a practical "science of science education."

6. National Trajectory in Science Education

The schools in New York, and the larger frustrations surrounding all demands for deeper evaluation and reform, must be put into a national context. The upshot is that over many decades, the trajectory of U.S. science, technology, and mathematics education has been downhill. It is a well-documented, rueful tale.

History of Concern and Failure. For fifty years, as the U.S. National Science Board declared in 2000, professional scientists, engineers, and mathematicians have "expressed grave concerns...about the quality of pre-college instruction...because the curriculum (is) badly out of date...and instruction (is) too passive for children to develop a genuine understanding of the key concepts and ideas" (15). In every international comparison, the average performance of U.S. high school students is shoddy. The data reveal a consistent pattern: teaching in the middle and high schools does not fulfill the promise of generally satisfactory preparation of students in elementary schools. [It is much the same in England, according to a recent parliamentary committee that said science lessons for 14-16 year olds are "boring" and turn students off science for life (15a).] As a result, high school graduates are barely literate, thinly numerate, ignorant about science. This is an abominable basis for entering college or starting jobs. Universities and employers must provide remediation to bring entry-level individuals up to an acceptable level (16).

Educational historian Diane Ravitch recently assessed the past century of U.S. failures in education. With stinging specificity she documents how the steady drop in enrollments in high school science and math was the direct result of imposing fewer requirements and permitting more electives in "soft" subjects for graduation (17). Ravitch also confirms the facts about an even more serious general lowering of academic standards, and she exposes the flimsy rationale for setting such sharply reduced expectations of high school students. In her trenchant critique she reveals why the cycles of repeated failure and disappointment have been so hard to reverse.

Twenty years ago, *A Nation at Risk*, the dramatic report by the National Commission on Excellence in Education, cried alarm about these trends. Members of this extraordinary Commission included distinguished scientists such as William O. Baker, chemist and former president of the Bell Laboratories. The Commission boldly warned that the educational foundations of American society were "being eroded by a rising tide of mediocrity." Their stalwart attack took hold in the public's mind because citizens understood it was true. Yet after almost a generation, despite the investment of enormous new energy and resources, little has changed. The Commission's recommendations were anchored on the idea of "the new basics," which would encompass in high school mandatory three years each of mathematics and science along with a half-year of computer science (18). But most students today still take only one year of science and math.

In 1989, stimulated by the Commission's 1983 Report, President George Bush tried as hard as any president ever had to reverse the downward trends. He gathered all of the nation's governors to confront the issues and then chart objectives to be met on a timetable. Meeting at the University of Virginia in Charlottesville—a perfect setting for renewing Jefferson's commitment—the group agreed on six goals to be achieved by the year 2000. One was to enable "U.S. students (to be) first in the world in science and mathematics." As Bush's Science Advisor, physicist D. Allan Bromley later wrote: "Even those of us who had gone to the (Education) summit with a reasonable degree of skepticism—perhaps even cynicism—came away tremendously encouraged but fully aware of the monumental problems that lay ahead" (18a). Monumental, indeed. The goals for 2000 were not met, not even approached during the 1990s. Bromley concludes his cogent review of the challenges for mathematics and science education by declaring "unless we can rebuild our pre-college educational system, then almost all of the other good things that we plan for the future will simply not occur" (18b).

Molecular biologist Bruce Alberts, President of the U.S. National Academy of Sciences, conceded in 1997 that "there has been much discussion of improvement in science education, but only marginal progress" (19). Having worked diligently in California schools, he offered a powerful observation: "Kids hate science for a reason. As structured and presented (in most textbooks and by most teachers) it is deadly dull" (20). Sounds like the British critique of this year. By the mid-1990s, because so many leaders and initiatives had achieved so little success, even ardent science educators were doubting the feasibility of ever making a dent. Morris Shamos, for example, a physicist and long-time faculty member, said: "Having given the problem our best shot, so to speak, and failed, we must now seriously question the premise of general education in science, that is, of science education for the non-science student" (20a). Few others were this pessimistic. But his well-reasoned critique was another red flag marking the problem.

Possible Solutions. What can be done? During recent years many U.S. groups have and made superb suggestions.

The National Research Council, for instance, examined a range of desirable economic incentives (21). But the U.S. still has not instituted any financial incentives significant enough to make a major difference for school reform. In another initiative, Sigma Xi, the honor society of scientists, shrewdly assessed options for the most effective action at the local level (22). But few lasting and systemic commitments were attained, despite the optimism born of many encouraging *ad hoc* demonstrations. The American Association for the Advancement of Science, through its productive Project 2061, entered the fray in 1989 with wise and visionary recommendations for "science literacy goals" (23). But, sad to say, the U.S. has not, as AAAS hoped, "transformed its schools to make scientific literacy possible for all students."

Another source of the many major proposals for change, was the Carnegie Commission on Science, Technology, and Government. It focused on the Federal government's leverage in reforming K-12 science and math (24). But since Washington provides less than 10% of the national investment in education at the elementary and secondary levels, and because the federal agencies do not coordinate their programs very well, little changed. The single exception at the Federal level is the enhanced commitment by the National Science Foundation.

What about considering more emphasis on technology in the curriculum? One idea is to bring students to enjoy science by first helping them to explore the technological environment they love: computers, CDs, cars, environmental pollution, construction of buildings, design of musical instruments. After all, Feynman repaired radios on the streets and Sacks loved chemistry in the basement. Another idea is to exploit the information and communications technologies. Most professionals agree with the White House Science and Technology Office's urging to draw on the enormous powers of information technology in the classroom--both as stimulus and as a resource (25). Yet so far these approaches have yielded more hope than results. None has had major impacts. Few have continuing champions.

Teachers. Given scores of thoughtful recommendations—in the glare of declarations that insist upon higher standards, papering the walls of schools everywhere—why are improvements so slow? I believe an important reason for the glacial rate of change is the inadequate background of most middle school teachers of math and science. To correct this problem, retraining—or as educators prefer, "development"—of teachers has been undertaken by many universities and research leaders. At the New York Academy of Sciences, a pilot program called SP^{3}ARK, funded by the National Science Foundation, demonstrated that more effective "inquiry-based" science teaching can be achieved by conducting intensive workshops in the summers, adding modest resources for simple investigations in the classroom, and re-enforcing the hands-on approach throughout the school year (26). But in this battle to improve science teaching, too few teachers have been reached, too few schools are committed, and too little diffusion of "best practices" has been promoted. I will offer a proposal—a "cure", if you will—about teachers in my concluding section.

Competition. An incendiary new concept in the battle for reform in U.S. schools is the proposal to create competition against the inert public system. A major argument in this national debate is the imperative to gain better science and math teaching.

Recall that Jefferson and successive American Presidents believed in mandatory public education for every citizen (although scattered private academies always were part of the American system). Public elementary and secondary schools—and public universities since the mid-19th century creation of the land grant system—have been accessible to anyone. This open, free system produced literacy for all, new opportunities for immigrants, and gifted alumni in every field.

But what about the public school system's "monopoly" position? Critics say that for the elementary and secondary levels—in contrast to the amazing diversity and razor sharp competition among colleges—the almost complete lack of competition is the main reason for miserable performance. In short, if the public system's monopoly is the brake on reform, why not try "vouchers"? The idea is to give back to parents their tax money to spend wherever they choose to educate their children. For the past decade this idea has been ripping through the U.S.

Cleveland's experiment with vouchers was tested in the Supreme Court on the grounds that most, or at least some, of the money will go (and, in fact, has gone) to religious schools (27). The First Amendment constitutional argument—that government must be separate from the church—had loomed large. A few private, profit-making (or at least, profit-seeking) firms are also in the battle to compete with the existing flotilla of public schools. In a perceptive lecture on the underlying reasons for the present frustration and dissension about schools, especially in urban areas, political theorist and legal scholar Stephen L. Carter points out that, "A majority of the parents of public school children say they would send their children to private schools if they could afford it—and, of those, the overwhelming majority say they would choose a religious school" (27a).

Carter anticipated Chief Justice Rehnquist's view that since parents decide where dollars go, vouchers are a "program of true private choice." Accordingly, the Supreme Court ruled on June 27, 2002 in a 5-to-4 decision to permit vouchers. This will free parents and students—and teachers—to make private choices in a competitive system. The overall governance of education in the U.S. surely will begin to change. It may shift, for example, toward a model resembling the way FDA controls pharmaceutical firms by requiring robust evidence showing the safety and efficacy of new drugs. Similarly, the educational system would evolve a new set of institutions, data guidelines, and performance standards requiring any school to show competence in order to become eligible to receive tax-based funds in the form of vouchers.

With that evolution, education then would no longer be the widely diffused responsibility of thousands of decentralized local school boards. Yet these boards, politicized and sluggish though they may be, are among the most prized fixtures in the traditional American scheme of educational values. In many senses, they are the embodiment of Jeffersonian democratic action at the local level. So is it risky to place education in the hands of unaccountable groups who show, on a competitive basis, that their methods actually work to meet national standards? Are the voucher experiments in Cleveland blazing a new trail or undercutting a unique American strength?

No doubt the revolutionary shift to vouchers would demand that citizens understand *caveat emptor*. Parents would have to invest in the effort to make informed choices. But parents already are rebelling in this spirit. Philadelphia's badly failing school system, the seventh largest in the U.S. with 200,000 students and a $1.7 billion budget, may soon be managed (or "taken over") in part by the commercial firm Edison Schools, Inc. while a Pennsylvania commission rules how to proceed in the future (28).

Elite Universities and Mediocre Schools. Against the background of these cross-currents affecting the U.S. educational system as a whole, what is the bottom line? As Cal Tech physicist David Goodstein asked: "How can (the U.S.) miserable system of (elementary and secondary) education have produced such a brilliant community of (university, government, and corporate) scientists?"(29).

The primary answer is not the immigration of talented and ambitious foreign citizens, although America has attracted many. The answer also is not funding, although research funding to universities has increased dramatically throughout the country since the 1950s. The explanation, argues Goodstein, is that the U.S. educational system is not a "pipeline," but a "mining and sorting operation." It is designed to discover rough diamonds and polish them. So the U.S. graduate schools are elite, while its secondary schools are barely able to alert most citizens to the rudiments of science, math, engineering, and medicine. This pattern may sustain U.S. research leadership, but it undermines strength in the larger economy. For today's student, in bleak and troubled schools, the future workplace calls for greater skills than most schools furnish. That is the case, I think, throughout NATO's member countries and around the world.

7. Public Understanding and Support of Science

Science generally, and science education in particular, improve only when, and only to the degree that, a society assigns these goals a national priority.

Confidence in Science. The National Science Foundation's biennial publication of "indicators" is the single best source of data about public attitudes and understanding of science and technology in the United States (30). Most evidence demonstrates that Americans have high confidence in science. For example, 90% agree that science and technology make lives "healthier, easier, and more comfortable" (31). To be sure, reservations also exist, as 40% say "science makes our way of life change too fast." Overall, U.S. citizens support science and technology, and they are overwhelmingly (82%) in favor of governmental funding of basic research (32).

These positive views correlate closely with educational level: on average, the more education a person has, the more the person pays attention to and supports science and technology (33). In a sense, then, when high schools prepare students badly, and graduates do not or cannot move ahead in education and work, a vicious circle may be perpetuated that leads citizen-parents to settle even more complacently for mediocrity in school science. Rising interest in creationism seems to reveal public vulnerability to junk science.

Unease. Despite America's general confidence in science, cross-currents of unease and dissent are not hard to find. From the 1960s protests about the high-technology war in Vietnam to the 1990s anti-WTO campaigns about technology-driven globalization, evidence of public sympathy for "going slow" has been around for a long time. Physicist and historian Gerald Holton opened a candid reevaluation of deeper issues when he commissioned a series of essays with this outlook: "...the old model of value-free science unlocking the secrets and powers of nature for man's benefit has had profound social and intellectual consequences...(and) searching thinkers both in science and outside are troubled by the new images which at their fashionable extremes project science as almost mindlessly giving, to unprepared or unwise people, uncontrolled powers over nature and human life" (34).

For physicist Steven Weinberg, "public attitudes toward science, favorable or unfavorable, are shaped far more by the expectation of good or evil technological developments, than by approval or disapproval of the scientific enterprise itself" (35). Most surveys confirm Weinberg's notion. The NSF data show almost half the U.S. public worries about nuclear power, genetic engineering, and space exploration (36). For such controversial applications, a citizen's worry generally declines with more education, but not always.

Capacity of the Public and Media. In contrast to these pessimistic perspectives, one encouraging study suggested that "the general public has the ability and the willingness to assess thoughtfully even very scientifically complex issues featuring areas of substantial expert uncertainty" (37). This result depended upon conducting extensive exchanges—an "educational intervention," which unfortunately would be impossible to conduct throughout the country—with the guidance of professional moderators and researchers who helped the participants understand the basis for complexity and choice. Differences in each individual's values, not in their formal expertise, caused judgments to differ. So it is possible to argue that the present low level of science education of many citizens does not necessarily endanger their effective, informed participation in democratic decision-making if major educational campaigns on each issue were feasible. But this does not mean that most citizens can develop their full potential with sadly inadequate science and math. Individuals cannot thrive in today's workplace as technical illiterates.

After school, then, where do citizens and students acquire the information on key public choices? The media are the main source. Issues with complexity—say, the uncertainties surrounding projected long-term effects of global warming—pose special challenges for the media. According to one study, "science is literally a life-and-death news story that threads its way through every aspect of American culture—and the media leave the public mostly ill-informed about it" (38). Any criticism of unfolding "consensus" views appears as cranky dissent, not as a valuable contribution to research-in-progress.

The problem, said one study, is both "the attitudes of ignorance by journalists and arrogance by scientists, standing in the way of public understanding of science and the need to bring these worlds closer together" (39). This stinging criticism helps to explain some of the public's interest in non-scientific phenomena, such as the paranormal. As many as one-third of Americans believe in astrology, the notion that the position of planets affects people's lives (40). What a sad state of affairs: while astounding new understanding of the universe comes out every day from modern astronomy, few Americans hear those findings and many find refuge in ancient superstition.

Such junk science thrives on ignorance. Former White House Science Advisor John Gibbons framed the issue well when he said, "I am sure there are some flat-earth people around somewhere. But I think it's important for us in the science community and in the journalism community to understand the process of science...when conflict is misinterpreted or misused, as it is more frequently these days, that's our problem" (41).

Sound bytes, hyped conflicts among experts, impatience with the details of probabilistic assessments—whenever these features drive the media's approach to science and technology, public appreciation of reliable knowledge declines. For the scientific community, more frank self-criticism about uncertainties would be useful. For the media—and for teachers—more searching exchanges would be productive. Schools should help, but rarely do.

Deeper Fissures. Before closing this overview of national trends, three deeper points must be considered. The first relates to the social expectations for education in the U.S. culture, the second concerns economic prospects, and the third focuses on American attitudes toward intellectual life. I cannot elaborate these complex matters. But I believe they profoundly affect the U.S. scene. I also believe these factors are significant elsewhere, even if expressed differently in other cultures.

Social Mobility. Political economist Richard Leone points out: "Capitalism and democracy owe a large measure of their dynamism and success to the fact that, while they do not prevent substantial inequality, they do offer extensive opportunity for upward mobility...(but) the reading gap between the average student in high-poverty and low-poverty schools starts at twenty-seven points in first grade and grows to forty-three points by eighth grade" (42). This is the frustration, underscored by Stephen Carter, that leads parents in urban areas to seek the choices made possible by vouchers. Science and math scores generally run in the same directions as reading scores with the same gaps, perhaps worse. About half of the U.S. families in city schools—the schools most demoralized by such miserable performance—may lose confidence in America's social opportunities. Furthermore, success at the high end of U.S. science will not be sustainable unless social dynamism through the schools—whether public or private—can be restored. The educational system's ability to open social opportunities and teach responsibilities—among Jefferson's ideals for democracy—depends in this century more and more upon scientific literacy.

Economic Prospects. "Human capital," in every nation, as economist Theodore Schultz emphasized, means the "acquired abilities of people" and this determines the "future productivity of the economy" (43). For the 21st century's knowledge-based competitions among people, firms, and nations, a grasp of science and math is indispensable. Data confirm the trend: in the U.S. "each year of schooling raises a person's wage on average by about 10 percent...and in less developed countries the gap is even larger" (44). Even for low-technology services and manufacturing, a modicum of technical dexterity has become a prerequisite of employment. A 1998 U.S. Census Bureau report said that "one of the most convincing (reasons to pursue higher levels of education) is the economic return associated with increased schooling" (44a).

Anti-Intellectualism. The consequences of America's long-running anti-intellectualism may well be the major undertow dragging down the quality of U.S. schools in science and math. On this lamentable point, intellectual historian Richard Hofstadter's classic analysis merits rereading. His assessment raised the paradox of education in a democracy and in American life: in a society "so passionately intent upon education, the yield of our educational system has been a constant disappointment" (45). He notes "a prevailing concern that children not form too high an estimate of the uses of mind" (46). He documents that throughout the 19th century, salaries for teachers were low, the preparation of teachers was mediocre, and students saw that teaching was an unattractive profession. By the early 20th century, "the child was conceived not as a mind to be developed but as a citizen to be trained" (47).

Hofstadter criticizes educational leaders who in the 1950s aimed "to make completely dominant the values of the crusade against intellectualism," largely by watering down the classic requirements for languages and math while raising the banner of "life adjustment for all youth" (48). Ironically, the behavioral sciences were often invoked to press the validity of this crusade. As Hofstadter ruefully notes, "life adjustment educators would do anything in the name of science except encourage children to study it" (49). Nerds were not welcome. The curious were questionable. This is not fertile ground for raising a crop of first-rate science students in the schools.

Although these three forces cramp every action to reform science education, a measure of lingering optimism is warranted. After all, a responsible program for K-12 science and math education can be justified by the American promise to enable social mobility. Reforms can be promoted by the economic imperative to create a technically literate workforce able to compete globally. The chronic danger to reformers is still from those who wish to dumb down the curriculum, succumbing to anti-intellectualism. But the public soon may see that, however threatening or elitist a creative education may be, national success in the future demands rigor in education today.

8. Illustrative Proposals for Turnaround

Many enemies of change threaten U.S. education: the daunting complexity of the system, the populist drag on elitist goals, and tradition's heavy anchors. These forces appear in the assessments by educational historians such as Ravitch and intellectual historians such as Hofstadter. Nonetheless, a major turnaround must begin. Consider three proposals that would jump start the process of lifting the quality of science and math education.

Merit Incentives. The first is to provide substantial pay incentives for teachers who demonstrate high levels of competence in subject matter and who show unequivocal dedication to the mission.

One mechanism would be to organize a new national program for Ph.D. candidates in the natural sciences, mathematics, and engineering to compete for full graduate fellowships at universities of their choice. In return, the winners would work for, say, five years in the public middle and high schools. Mathematician and entrepreneur James Simons likens this approach to the prodigiously successful federal fellowships offered after Sputnik in the late 1950s and 1960s.

An alternate scheme, fulfilling the same purpose, would be to offer a voluntary exam to all science and math teachers on the content of the courses they teach, e.g., algebra, chemistry, astronomy. Those scoring in the top 10% would receive bonuses of, say, $25,000 per year for their agreement to remain public school teachers for five years. Such "masters" of content would become models. They would raise the bar for the profession, attract bright young people to teaching, show students that science and math command vital support.

Blocking the road to such meritocratic ideas is the education establishment's obsession with a teacher's formal training in pedagogy—almost to the exclusion of assuring the teacher's knowledge of the content of a course. This leads to comically sad consequences. For example, John Brademas, the distinguished former long-time Congressman (D., Indiana), a leader in national educational initiatives, a gifted scholar, and former president of New York University, offers the following anecdote: "...when I returned from Oxford to my home town of South Bend, Indiana and, already thinking of running for Congress, went to the local school superintendent to see about teaching in the local public schools, although I had a Harvard undergraduate degree, one year of graduate school at Harvard and an Oxford Ph.D., I was unqualified in that I had had no courses in pedagogy." The children of South Bend were the losers.

In President Bush's State of the Union message in January 2002, he asserted an unexceptionable "great goal for America: a quality teacher in every classroom" (50). A new federal program of merit-based financial incentives could help achieve his goal. It would revolutionize the quality of science teaching over the next decade, just as the post-Sputnik fellowships galvanized exceptional talent to work for the Department of Defense and NASA on advanced projects in the 1960s.

Competition and Innovation. The second proposal is to open all the gates for competition and innovation.

Let the answer be "yes" to every responsible experiment: charter schools, vouchers, larger pay incentives for principals running high-performance schools, wider administrative leeway for firing low-performance principals and teachers, novel and longitudinal evaluations of what works. In short, let there be more diversity and economic rewards, sterner accountability, serious research on education, and broader choices everywhere. Could such a messier, dynamic marketplace be worse than what most urban schools are today?

For science and math, the corollary is to restore stringent requirements for graduation—why not national standards?—within this competitive framework. Only by asking more of students will a competitive system yield the desired achievements. Even without a competitive system for parents' choices of schools, there is little excuse for asking so little in the science and math curricula.

One powerful way to enhance the demand for improved science education is to bring more local resources to students—to stir interests of the kind shown by Oliver Sacks. This can now be done much more effectively through physicist Alan Friedman's innovative work at the New York Hall of Science (www.nyscience.org) and his orchestration of a global linkage of museums (www.tryscience.org). On the local level, especially in urban areas, schools can take advantage of capabilities at universities, health centers, government agencies, and corporations. The New York Academy of Sciences has launched an electronic clearinghouse with 300 such resources ("sciedunet" at www.nyas.org).

Role of the Universities. My third proposal is to create incentives to expand the range and reach of science-rich universities in helping science-poor schools.

Federal and state governments, foundations, companies, corporations, private donors—together with university executives—should frame long-range mechanisms for stimulating faculty to assist teachers in the classroom. Physicist Leon Lederman emphasizes "hands-on, activity-based, inquiry-led" science teaching at all levels. Along with his cogent advocacy to put physics first, then chemistry, and last biology in the high school sequence, his approach naturally creates an imperative for professional scientists, mathematicians, and engineers to collaborate more widely with teachers to orchestrate the needed major changes (51). Despite occasional surges of *ad hoc* efforts, however, substantial school-university links do not exist. Such collaborations are difficult and time-consuming, because meaningful success requires going well beyond one-shot demonstrations and lectures. Yet reviews of successful programs do show what works (52).

But faculty at major research universities generally confront heavy disincentives when they consider taking responsibilities in K-12 education: risks to gaining tenure, especially for young faculty; risks to sustaining research productivity and funds; risks to scholarly reputations. One way to reduce these risks is to create a new safety margin on the clock for granting tenure; for example, add two years to the clock if a junior faculty member spends one day per week in the local schools. Another step is for sponsors to provide a modest funding increment, say 5-10%, in research grants in order to enable new and continuing K-12 efforts; this will encourage well thought through, add-on initiatives. Such experiments should be considered by national university associations as well as by the leaders of campuses in those urban areas afflicted with the most dysfunctional schools.

None of this will work without high-level encouragements by deans and presidents. Why should university executives endorse high-quality K-12 collaborations by faculty? Why not? After all, the long term benefits of these collaborations are entirely consistent with the underlying objectives of universities: buttress the national science base, lift scientific awareness of all students, identify great talent, and strengthen the human capital for economic vitality. Universities that become more intensively engaged with secondary schools also will see even more clearly whether standards for graduation from high school should be reset, and presumably raised, with respect to science and math.

Impacts. One of the largest benefits in pursuing these proposals, reaching all students with a stronger science/math curriculum, would be the positive impact on girls. Data confirm that girls seldom perform on average as well in secondary schools as they did in elementary grades. Women faculty must be more active in inquiry-based classrooms—and more role models must be given visibility such as in the American Weizmann Committee's Awards for Women in Science, established by the philanthropist and science education advocate Sara Lee Schupf. Then girls would be more likely to fulfill their potential in science, math, and engineering. MIT's frank 1999 self-assessments of the "plight" of women in research, and recently of women in its engineering school, concluded with a recommendation to double the percentage of women engineers within a decade (53). Such a goal—and similar ones set by many firms and research universities—will not be met unless middle and high schools perform more effectively for all students, particularly girls.

Final Note. I am keenly aware that some of the U.S. trends I have sketched—ranging across soaring aspirations and dispiriting results—are not precisely those in other nations. Yet the priority on education is rising almost everywhere and I am conscious of the great value of international exchanges, crossing many disciplines, about how science education can be improved. So, I am grateful to NATO—and to the workshop co-chairs, Peter Csermely and Leon Lederman—for the unusual opportunity to join this timely session on a subject of almost incomparable importance for society's future. I thank the Hungarian conference secretariat for their friendly and efficient hospitality, and I thank Florence Arwade for her flexible, intelligent, and patient assistance with the manuscript.

Notes and References

[1] *Jefferson The Virginian*, Dumas Malone, Little Brown & Co., Boston, 1948, p.101. Malone's Pulitzer Prize-winning six volume biography of Jefferson has repeated references to education.
[2] *Ibid.*, p. 281.
[3] *Ibid., p. 281.*
[4] *Ibid.*, pp. 281-2.
[5] *Ibid.*, p. 283.
[6] *The Sage of Monticello*, Dumas Malone, Little Brown, Boston, 1981, p. xvi.
[7] *Surely You're Joking, Mr. Feynman*, Richard P. Feynman, Bantam Books, New York, 1985, p. 254. [For a splendid biography of Feynman, see: *Genius*, James Gleick, Pantheon, New York, 1992.]
[8] *Ibid.*, p. 257.
[9] *Ibid.*, p. 257.
[10] *Ibid.*, p. 257
[10a]Kuo-ting Li, *The Evolution of Policy Behind Taiwan's Development Success*, World Scientific, Singapore, 1995; see especially e.g., pp. 154-157.
[11] Science Service, Directory of Science Training Programs, Washington, D.C., 1999.
[12] Jeanette Kim, unpublished Impact Study (1994-1999) of New York Academy of Sciences' Science Research Training Program, December 2001, private communication, 2002.
[13] *Uncle Tungsten: Memories of a Chemical Boyhood*, Oliver Sacks, Knopf, New York, 2001, p.41-42.
[14] *Ibid.*, p. 154.
[14a]See budget summaries in AAAS, *R&D for FY2003*, Washington, D.C., 2002, pp. 55 and 85.
[14b] See, for example, *New York Times*, March 27, 2002 (p.B9), March 28, 2002 (p.A1), and March 29, 2002 (p.B4). Such controversies are chronic because evidence appears to be inconclusive.
[15] *Science & Engineering Indicators – 2000*, National Science Board, Arlington, VA., NSB-00-1, p. 5-3.
[15a]*Nature*, Vol. 418, 81 July 2002, p. 266.
[16] *Ibid.*, The NSB chapter carefully integrates a wide range of sources commenting on the interactions among factors such as curricula, standards of performance for students, and the international context for U.S. elementary and secondary education, focusing on science and math. The dark implications for the workforce are all too clear.
[17] *Left Back: A Century of Failed School Reforms*, Diane Ravitch, Simon & Schuster, New York, 2000, p. 350 and p. 404; This critical history assembles and interprets an enormous array of primary materials.
[18] *A Nation at Risk: The Imperative for Educational Reform*, National Commission on Excellence in Education, Washington, D.C., U.S. GPO, 1983.
[18a]*The President's Scientists: Reminiscences of a White House Science Adviser*, D. Allan Bromley, Yale University Press, New Haven, 1994, p. 110.
[18b] *ibid.*, p. 121
[19] *Science Education: Challenges and Solutions*, Science in Society Policy Report, New York Academy of Sciences, New York, Feb. 1999, p. 11.
[20] *Ibid.*, p. 15.
[20a]Morris H. Shamos, *The Myth of Scientific Literacy*, Ruters Press, 1995, p. xiii.
[21] *Improving America's Schools: The Role of Incentives*, National Research Council, Washington, D.C., 1996. Dale Jorgenson points out that "skyrocketing education expenditures per pupil during the 1970s and 1980s had little or no payoff in enhancing the average performance of students." (p.6).

[22] *Scientists, Educators, and National Standards: Action At The Local Level*, Sigma Xi Forum Proceedings, Research Triangle Park, NC, 1994.
[23] *Science For All Americans*, AAAS, Washington, D.C., 1989.
[24] *In the National Interest: The Federal Government in the Reform of K-12 Math and Science Education*, Carnegie Commission on Science, Technology, and Government, Carnegie Corp., New York, September 1991.
[25] *Report to the President on the Use of Technology to Strengthen K-12 Education in the United States*, President's Committee of Advisors on Science and Technology, White House, March 1997: and *Technology In Society: An International Journal*, special issue on "Education and Technology: Asking Questions," Pergamon, Vol. 20, No. 3, August 1998.
[26] See Reference 19 above, Lori Skopp, pp. 22-8; and see, as an example of the contemporary debates on "professional development," three letters in *Physics Today*, January 2002, p. 10, especially with respect to "five elements" of systemic reform; professional development: instructional materials; administrative and community support; back-up system for materials; and assessments aligned with curriculum.
[27] See coverage in, for example, *The Economist*, 23 February 2002, p. 13 and pp. 35-6. During the 1990s public opinion polling about vouchers showed an even split about the wisdom of using vouchers. But "support for vouchers is strongest among those most directly served by public schools, those whose schools are viewed as having the most problems," and younger people; see Ref. 42, p. 277-78. Sol Stern visited four inner-city schools in Cleveland and Milwaukee and gave them "a straight A." (*City Journal*, Winter 1999, p. 14). Competing views in *The New York Times* editorial, "The Wrong Ruling on Vouchers," 28 June 2002, p. A26; and the *Wall Street Journal* editorial, "Vouchers Have Overcome," 28 June 2002, p. A12.
[27a]Stephen L. Carter, *The Dissent of the Governed: A Meditation on Law, Religion, and Loyalty*, Harvard University Press, 1998, pp.45-46.
[28] See, for instance, reports of situation by Brent Staples, *New York Times*, 24 February 2002, p. WK-12; and Queena Sook Kim, *Wall Street Journal*, 15 February 2002, p. B-2.
[29] *Engineering & Science*, David L. Goodstein, Spring 1993, p. 27.
[30] National Science Board, *Science and Engineering Indicators - 2000*, Arlington, VA: National Science Foundation, 2000, NSB-00-1.
[31] *Ibid.*, pp. 8-13.
[32] *Ibid.*, pp. 8-15.
[33] *Ibid.*, pp. 8-18.
[34] *Science and Its Public: The Changing Relationship*, *Daedalus*, Summer 1974, p. vi.
[35] *Ibid.*, p. 33.
[36] See Reference 30, pp. 8-19, 8-21, and 8-22.
[37] John Doble, "Public Opinion About Issues Characterized by Technological Complexity and Scientific Uncertainty," *Public Understanding of Science*, Vol. 4, Issue 2, April 1995, p. 99.
[38] *Worlds Apart: How the Distance Between Science and Journalism Threatens America's Future*, Jim Hartz and Rick Chappell, First Amendment Center, Nashville, TN, 1997, p. vii.
[39] John Seigenthaler, *Science*, Vol. 279, 27 March 1998, p. 2036.
[40] See Reference 30, pp. 8-31.
[41] See Reference 39, p. 150.
[42] *A Notion At Risk: Preserving Public Education As An Engine for Social Mobility*, Richard D. Kahlenberg, Ed., Century Foundation, New York, 2000, p.v-vi.
[43] *Investing in People*, University of California Press, 1981, p. 140.
[44] *Principles of Economics*, N. Gregory Mankiw, Drydon Press, 1998, p. 528.
[44a]Cited in *Wall Street Journal*, 8 April 2002, p. A26.
[45] *Anti-intellectualism In American Life*, Richard Hofstadter, Knopf, 1963, p. 304-5.
[46] *Ibid.*, p. 306.
[47] *Ibid.*, p. 335.
[48] *Ibid.*, p. 343.
[49] *Ibid.*, p. 345.
[49a]Private communication, July 2002.
[50] *President's State of the Union Address*, U.S. Capitol, 29 January 2002.
[51] See, for example, Lederman's presidential lecture to the AAAS, *Science*, Vol. 256, 22 May 1992, p. 1121; and his letter in *Physics Today*, March 2002, p. 11.
[52] A recent summary of practical lessons learned is "How Scientists Can Help With K-12 Education," Diandra Leslie-Pelecky, *APS News*, March 2002, pp. 5-6/
[53] *Science*, Vol. 295, 22 March 2002, p. 2192.

Science Education: Talent Recruitment and Public Understanding
P. Csermely and L. Lederman (Eds.)
IOS Press, 2003

Science magazines in North America

Jane ASPELL
SEED Magazine
206 rue de l'Hopital, Montreal, Quebec, Canada H2Y 1V8

Abstract: The article deals with the complex issues concerning the younger generation of scientists. It provides information on the International Forum of Young Scientists as an experimental approach in working for and with young scientists.

1. Science magazines in North America

You can easily identify them by their covers - spiral galaxies, rockets, ball and chain models of molecular structures - science magazines. Their aim is to popularise science, to make it accessible and attractive to non-scientists and to entertain and inform scientists who have interests outside their own specialised areas. Do they succeed?

Until the launch of *SEED* in November 2001 there were three main popular science magazines in North America: *Scientific American, Popular Science* and *Discover*.

Popular science magazines were founded in order to provide scientists with a forum to present their research to an educated public. When *Scientific American* was established, it sought to reach a more general audience than the specialist science journals that occupied the market at the time, most prominent among them being *Science* and *Nature*. While the specialist science journals are still going strong today, their reach is solely within the scientific community. *Scientific American* broke ground by reaching a larger public.

According to figures from the National Science Foundation database (see table 1) there is a potentially massive audience for science magazines. In the US three million people hold a degree in science/engineering and are employed in a traditional science/engineering occupation. Two million hold a science/engineering degree but are employed in non-traditional science/engineering occupation, and a further 92 million people are 'very interested in science' even though they do not hold a degree in a science subject.

Audience Data ("S/E" = science or engineering) in the United States

3M individuals (25-45) hold a degree in S/E and are employed in a traditional S/E occupation
2M individuals (25-45) hold a degree in S/E and are employed in a non-traditional S/E occupation
92M individuals (25-45) do not hold a degree in S/E and are "very interested" in science

Source: NSF Science and Engineering Database

Table 1: Figures for potential audience for science magazines based on NSF Science and Engineering Database

The number of people with an interest in science is only likely to grow as the world's conversation becomes increasingly science-centric. Cloning, stem cells, energy and bio-terrorism stories daily fill newspapers.

The place of science in culture is clearly not what it was when *Scientific American* was founded one hundred and fifty years ago. Today the new face of science is global, culturally relevant and market-savvy. Science is less and less an isolated world. It is now integrated into popular culture more than ever before.

Have science magazines kept up with the times? Who are *Scientific American, Popular Science* and *Discover* writing for now?

In a recent interview the Publisher of *Scientific American* asserted: **"Scientists don't care about their image; they care about their thoughts."** Bruce Brandfon, Publisher, *Scientific American*

And in an interview discussing his magazine's redesign, which omits people and illustration, the Editor-in-Chief of *Discover* noted: **"Most of our readers couldn't care less about people."** Stephen Petranek, Editor-in-Chief, *Discover*

We would expect this to be a self-fulfilling prophecy. If this is who they think their readers are, these are the readers they are going to get.

According to the National Association of Science Writers: **"*Scientific American* is caught in a demographic trap. Compare a fat 1980 issue to a skinny issue today. Feature pages are down, from 200 in 1980 to 100 today. Ad pages are worse, from 100 pages in 1980 to only 15 or 20 today. Aging readers don't sell advertising."** *The Newsletter of the National Association of Science Writers*, Winter 2001-02

Indeed, from an advertisers' point of view traditional science magazine subscribers are not very attractive – they constitute a demographic that is oblivious to market trends and is only somewhat impressionable. If scientists don't care about their image are they going to buy Prada and drink Absolut? The advertisers (e.g. Honda and Microsoft) that do buy pages in science magazines do so for 'reach'; science magazines serve as a cost-effective vehicle to reach large groups of gross consumers. Science magazines therefore end up with a limited number of ad pages from traditional brands for traditional customers.

Why should those of us interested in effective science communication care about this? We should be worried because these magazines are rarely reaching people under the age of 45 – the median ages of the readers of all three magazines is 42-45. The readership also skews very much to a male audience. What's more they are rarely reaching people who weren't already interested in science. They are preaching to the converted.

Why is this? Contemporary science media revolves around popularisation. Following this trend, multi-million industry leaders like *Discovery Communications, National Geographic* and *Scientific American* do not deliver content that addresses science's new place in popular culture. More importantly, and perhaps consequently, these media groups fail to attract a younger audience.

When popularising science, they invariably begin with a breakthrough published in one of the science trade journals. Through metaphors and illustrations, they seek to translate the scientific jargon into material that speaks to an educated reader. Often, this involves drawing reference to the "real world" – with some form of application mentioned, usually in technology or medicine.

But by starting with a scientific concept and then using an application of the science to help communicate the concept to the reader, the media is limited by the extent to which the science is actually applicable, let alone applicable to the reader. The media doesn't control the topic. It only controls its popularisation.

The editorial direction of these magazines does not begin by addressing the uniqueness of the readership; it begins with what's new in science. The magazines therefore have difficulty forming a face and an identity for themselves. And in order for a magazine to engage with its reader, the reader needs to see him or herself in the magazine.

Probably the most fundamentally inaccurate stereotype that plagues science is that scientists = science, i.e. that there is no clear distinction between the job and the people who do the job. The generalization is that, for scientists, the job is their life. Science is complex, esoteric and abstract. And the assumption is that scientists themselves can be characterised in the same way. As a consequence, scientists have been denied a scene. While there is a business scene, a fashion scene, a literary scene etc., science has never really had one. Is there anything that science magazines can do to change this situation?

2. An alternative approach: *SEED* Magazine

The alternative to the traditional methods of popularisation used by science magazines is this: start with the application, not the science. This is a complete reversal from traditional methods of popularisation. Rather than looking for "what's new and what's next" in science (as *Popular Science* says), look for what's new and what's next in the lives of the reader. Look to business, to politics, to the arts and to current events and ask the question: how is science influencing these areas of culture, and how are these areas of culture influencing science?

This is the approach taken by *SEED* magazine, the first global science and culture magazine. It is positioned at the intersection of *Scientific American* and *Discover* and culture magazines like *Vanity Fair* and *Wallpaper* (see figure 1). Its aim is to identify the ideas, trends and people that are influencing science's place in culture and culture's place in science.

According to *Science* magazine, "***SEED*** is science's ***Vanity Fair***"

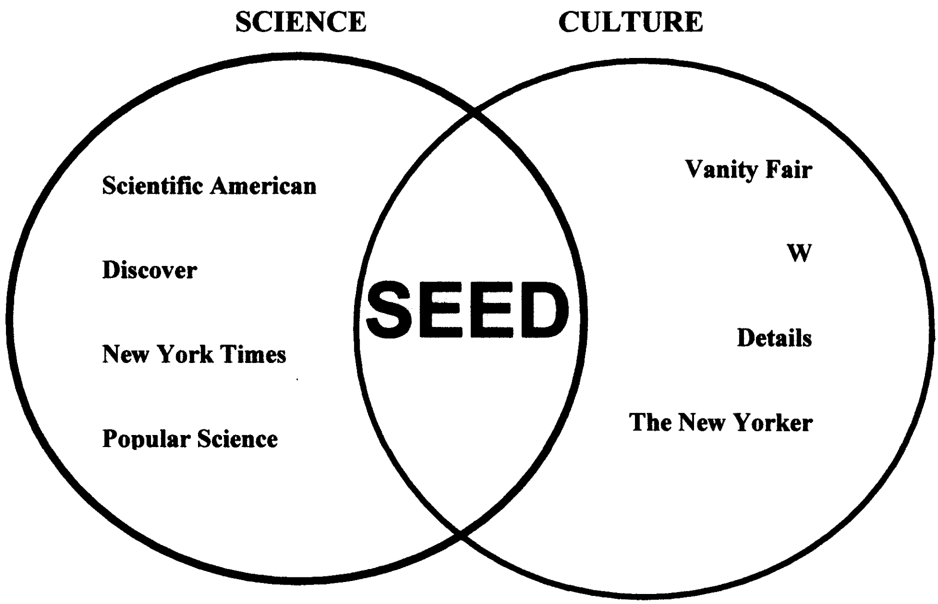


Figure 1: SEED is uniquely positioned at the intersection of science magazines and culture magazines

SEED intends to create a science scene for people at the intersection of science and culture. Science has lacked a face and *SEED* intends to give it one by presenting the people behind the scientific breakthroughs and the controversies, and by introducing readers to the people who are redefining science's place in popular culture. Giving science a fresh face may help make the discipline attractive to new generations of students who are very sensitive to popular stereotypes. We cannot deny the influence of the media, even on science education. The caricature of the geeky lab coat-wearing scientist, who lives in a world of his own has undoubtedly had a damaging effect on the degree choice of generations of students who want to study what they perceive to be 'cool' subjects like media studies and law. Shows like Ally McBeal, LA Law and ER glamorise the professions they portray while scientists on TV and on the big screen are either mad, bad or nerdy. Pronouncements like that by the *Scientific American* publisher only emphasise the stereotype.

Even so, public interest in science is higher than ever and the main reason for this is that science is now more relevant to the world than it has ever been before. There seems to be a real need and a market for a magazine like SEED that focuses on the interplay between science and culture.

The response to the first two issues of SEED has been extraordinary. SEED was named one of the top 30 international magazine launches of 2001.

One of the most notable launches of the year: Science has long been a field seemingly detached from popular culture, and magazines like *Discover* have attempted to close that gap. Yet *SEED* may just beat them to the task. Samir Husni, 'Mr. Magazine'

***SEED* buries the idea of the stereotypical scientist by providing a look into the lives of the young, hip and brilliant scientists of today and tomorrow** *NextTV*

The new, ultra-cool magazine's contributor list is impressive *Nature* Magazine

A giant beanstalk of culture will grow from this seed Matt Ridley, Author of *Genome*

The new way of communicating science that SEED embodies – that of presenting science in the context of the wider culture in which it exists, and which it influences, and which in turn influences it - need not be limited to a magazine. It should have implications for education. The applications of science are usually the end-of-chapter footnotes that the teacher often skips in a rush to finish the course. If this is turned on its head, if students are first shown how science is shaping culture and how culture in turn is shaping science, if they are allowed to see the relevance of science to the modern world and to their own lives, we will have pre-empted that age-old question, 'what's the point of studying this?' We will have shown them why they should care.

Opportunities for Realization of Potential in Science and Technology in Gifted Programs in Israel

Shlomit RACHMEL and Rachel ZORMAN
The Department for Gifted Students, The Ministry of Education, 2 Dvora Ha-Nevia St. Jerusalem, Israel

Abstract. Three different types of opportunities for gifted students in Israel to realize their potential in science and technology are described. One type of opportunity is acceleration, integrating university courses into the jünior high school and high school curriculum. Another type is enrichment in specific topics of interest. This is provided both in the curriculum and as an extra-curricular activity. A third type of opportunity is utilizing science and technology to serve the community. This opportunity is integrated into the curriculum of junior high school and high school.

1. Rationale

At present, 12,000 students in 3rd to 12th grades are identified as intellectually gifted in Israel. These students score in the 98.5 percentile on tests of general intellectual ability, tapping into verbal, mathematical and spatial abilities, and emphasizing abstract thinking, memory, analysis and generalizing conclusions. Three different types of programs are offered to gifted students. These include self contained classes, enrichment magnet centers and extra-curricular enrichment courses. Self contained classes operate in regular schools six days a week, catering to gifted students from large cities. Enrichment magnet centers are regional centers that pull out gifted students from their schools for a special program one day a week. Extra-curricular enrichment courses are offered to gifted students in the afternoon, after school. The decision which option to offer gifted students in a certain locale is a joint decision made by the Ministry of Education and district and municipality officials.

What are the goals of programs for the gifted in Israel? Zorman and Rachmel (1,2) delineate the goals for gifted programs from a holistic perspective, integrating cognitive, social and emotional aspects.

From the cognitive aspects, the goals include:
- Developing specific skills and abilities in various talent areas, in line with individual needs and interests.
- Enhancing the ability to consume information critically and effectively. Strengthening the tendency toward strategic thinking.
- Encouraging divergent and inter-disciplinary thinking.
- Developing the ability to cope with uncertainty and deal with complex problems.
- Enhancing the ability to produce knowledge in various fields of interest.

From the social aspect, the goals include:
- Enhancing moral decision making.
- Developing awareness of moral and social dilemmas.
- Strengthening sensitivity toward others.
- Developing the ability to work in teams.
- Accepting the need for autonomy, while maintaining reasonable limits for freedom.
- Developing social interest and commitment to society.

From the personality aspects, the goals include:
- Developing persistence in performing tasks and postponing satisfaction.
- Enhancing commitment to tasks.
- Encouraging originality.
- Enhancing curiosity.
- Encouraging daring to express unusual, out of the way ideas.
- Enhancing personal initiative.
- Developing competency, which includes knowing what I am capable of, comprehending how I can make a difference and how I can cope with stereotypes.

In light of the above goals, the mission of gifted programs is to enhance individual capabilities in various talent areas from cognitive, social and emotional angles. Since gifted individuals are diverse in their interests, it is important to do so in specific talent areas. Science and technology comprise one of the major talent areas in which gifted students in Israel display their interest and talents. Therefore, it is imperative that we help gifted students actualize their potential in science and technology.

The Department for Gifted Students in the Ministry of Education instituted a variety of initiatives to enhance talent in these fields. The initiatives range from acceleration to enrichment with special emphasis on utilizing science and technology to serve the community. In this paper, we will describe each of these initiatives and provide examples of how they are implemented in gifted programs throughout Israel.

2. Acceleration

Acceleration enables gifted students to pace their learning at a faster rate than usual and learn advanced material beyond their grade level. Acceleration may be performed in different ways (3). One way is to enable gifted students to skip grades in school, consequently finishing their formal schooling at a younger age. Acceleration may also take the form of concurrent enrollment in university courses while studying in high school. This is usually done for gifted students demonstrating highly developed talent in a specific field. Acceleration may also entail early entrance to the university to pursue higher level studies.

In the United States, acceleration is offered by various universities to students highly gifted in mathematics and science. One of the most established acceleration programs is SMPY (Study of Mathematically Precocious Youth) that is operated by Johns Hopkins University in Maryland (4). The university offers various courses to mathematically precocious students and, in certain cases, accepts younger students for a full program of academic study. Several longitudinal studies that followed up students who accelerated their studies in such a manner after ten years (5,6) demonstrated that in comparison to their talented peers who did not choose to accelerate their studies, their academic achievement was more impressive. Moreover, they did not show any special social or emotional difficulties and their social and emotional adjustment was adequate. However, it is important to note that acceleration requires a willingness to break away from peers and an emotional maturity. Two case studies of professors of physics and astrophysics who participated in the SMPY acceleration program (7) demonstrate this clearly. These professors enrolled in the university in a full program of study at an early age. They reflected about their academic and social experiences as rapidly accelerated students and reported that acceleration was beneficial for them, both academically and socially, since it allowed them to proceed at their own pace and meet peers who shared their interests. However, they stressed that since acceleration is very demanding, both academically and emotionally, it may not be the answer for every gifted student. Therefore, one should consider its appropriateness for gifted students on an individual basis.

In Israel, there has been great reluctance among educators to accelerate the studies of gifted students, for fear that acceleration may cause difficulties in their social and emotional development by increasing the already existing gap between their social and cognitive development. Therefore, grade skipping and early entrance to the university for full academic studies are rarely performed and then, only in individual cases.

However, in view of the favorable study results of acceleration and in light of the need to provide gifted students with a more challenging curriculum, the Department for Gifted Students initiated an acceleration program for gifted students in the academic year of 2000-2001 together with the Open University in Israel. The program is intended for gifted students in the ninth grade and up, who study in self contained classes six days a week. The objectives of this program include:

a. Providing an opportunity for academic enrichment during the regular school day.
b. Providing an option to specialize in a specific field in the sciences and get a Bachelors degree in it, while still in high school.
c. Developing independent learning and problem solving skills.
d. Enhancing social skills by creating a framework for gifted students to meet with their peers from different locales and share their interests.

How does this program operate? Gifted students from the ninth grade and upwards who attend self contained classes in junior high schools and high schools in the central part of Israel (mainly in Tel-Aviv and its surrounding cities, Herzeliyah, Petach Tikva, Rishon Le-Zion and Ramat Gan) are invited to come to one of the campuses of the Open University to attend one course of 3-4 hours every week. The students attend the course for a full semester. From the second semester onwards, students can choose to take two weekly courses. Students are offered help by advisors from the Open University to select the courses that they are most interested in. The program is unique in the sense that the students are accelerated in classes with their gifted peers from other locales. Thus, they remain in a familiar milieu of teenagers and are not entirely cut off from their schools. In addition, the program is part of the school day. On the day the program is held, students study in their own schools for a few hours and in the late morning they come to the Open University campus. Furthermore, a special coordinator from the Department for Gifted Students accompanies them during their studies on campus to provide them with support, help them cope with various difficulties and mediate between them, their respective schools and the Open University, should the need arise.

The method of study is different from the usual lecture, readings, papers and/or tests. Students are provided with a comprehensive textbook, which contains specific units of study, complete with independent study tasks that require analysis and application of the knowledge and skills learned in each unit. Students are expected to read the unit before each class. In class, they discuss various issues and questions that relate to the unit and receive extra help from the instructors, according to need. At the end of each unit, they are required to complete the independent study task on their own. They may contact the course coordinator during the week by phone to answer further questions. The independent study tasks are quite elaborate, requiring at least 4-5 hours for completion. At the end of each semester, they also have a final examination in each course.

Formative assessment is conducted on a continuous basis to provide information on the following issues:

1. How is the program structured and does this structure provide an adequate answer to student needs?
2. Is the program organized effectively and does it promote a positive social climate?
3. What are the outcomes of the program and how do students perform in the courses that they study?

The above issues are examined on the basis of information gathered from a variety of sources and perspectives. These include student questionnaires, personal interviews with school principals, students and the program's coordinator, and analysis of documents and reports.

In the academic year of 2000-2001, 97 ninth and tenth grade students participated in the program in the first semester and 77 attended courses in the second semester. In the academic year of 2001-2002, 104 ninth, tenth and eleventh grade students attend courses in the first semester. Most of the students took courses in mathematics and computers. In the first academic year, 89% of the students reported that they enrolled in courses that were their first choices. Most of them attended class meetings regularly and expressed satisfaction from the campus location and from the travel back and forth from the campus on a regular school day.

Information about the program's effectiveness from academic and social perspectives was initially gathered from student responses to questionnaires. Table 1 presents the means and standard deviations (SD's) of these responses for the main aspects of academic functioning on a scale of 1 to 5, where 1 indicates a very low degree of agreement and 5 indicates a very high degree of agreement.

Table 1 – Student responses to academic aspects of program functioning (means and SD's)

Academic Aspects of Program Functioning	Means	SD's
Instructor expresses readiness to work with students after class	4.07	0.88
The professional level of the instructor is high	4.21	0.80
The independent study tasks are clear and detailed	3.34	0.97
The instructor's comments on the independent study tasks are clear and detailed	3.34	1.20
I am satisfied with the grades that I get on independent study tasks	2.94	1.30
Instructor expresses readiness to work with students after class on the independent study tasks	3.68	1.25
The program coordinator is responsive to the students	4.17	0.80
The program coordinator is updated and involved in the program	4.23	0.84

These student responses indicate that, in general, instructors express a high degree of readiness to work with them after class, both on general topics, as well as on independent study tasks. Moreover, the independent study tasks and the instructor comments on them were perceived by students to be clear and detailed. Except in one course, students expressed a considerable degree of satisfaction from their grades on independent study tasks. On further investigation of the course with the least satisfaction, it turned out that the problem was with the way the independent study tasks were graded by an external evaluator. This was relayed to the staff of the Open University by the program coordinator and corrected. We would like to emphasize that the above student responses demonstrate the centrality of the program coordinator to the well being of the students. 65% reported that they go to her whenever they experience problems or difficulties. Thus, they need someone who listens to them, someone who can provide them with information, who can offer them advice and mediate between them and their schools, as well as the Open University.

Table 2. presents the means and standard deviations (SD's) of student responses for the main aspects of social functioning on a scale of 1 to 5, where 1 indicates a very low degree of agreement and 5 indicates a very high degree of agreement.

Table 2 – Student responses to social aspects of program functioning (means and SD's)

Social Aspects of Program Functioning	Means	SD's
I have good friends in the campus	3.02	1.28
I spend time with friends from the campus outside of class time	2.23	1.41
My connection to students from my school strengthened	2.97	1.26
I have acquired new friends during my studies in the campus	2.58	1.34
People who study in the campus compete against each other	2.11	1.35

It is important to note that even though no special social activities were conducted in order to enhance group cohesiveness, as a result of the demanding courses in the program, it seems that students have good friends in the campus and they do not feel that there is an overly competitive atmosphere there. Moreover, students reported that their relationships with other students from their own school were somewhat strengthened, probably on the basis of shared interests.

In order to help students cope better with the challenging tasks that this acceleration program presents, they were asked to rate to what degree they experienced different sources of difficulty on a scale from 1, indicating a very low degree, to 5, signifying a very high degree of difficulty. Their responses are summarized in table 3.

Table 3 – Student perceptions of sources of difficulties (means and SD's)

Sources of difficulty	**Means**	**SD's**
The academic content of the courses is boring	2.74	1.24
The requirements of the courses are too demanding	3.25	0.96
The independent study tasks are too demanding	3.71	1.01
The independent study tasks are too difficult	3.35	1.07
The professional level of the instructors is unsatisfactory	1.98	1.22
The academic content of the courses is hard to understand	3.04	1.00
There is not enough time for studies in school	3.42	1.31

It seems from the above table and from group interviews with the students that the courses are quite demanding. The greatest sources of difficulty are the independent study tasks in the courses, which are difficult and too demanding, mainly in terms of study time. Therefore, students complained that there is not enough time for completing their homework in school. This difficulty was compounded by the fact that on the day that the students studied in the Open University, they missed out on some courses in their schools. Although the school principals agreed to provide enrichment courses on the day the gifted students attended the Open University program, some schools conducted regular courses, leading to conflicts in terms of getting the materials missed and attempting to complete school assignments given on that day. This problem was especially acute in those schools where only a small number of students chose to attend the Open University acceleration program. Other schools offered some unique activities on the day of the Open University program, which the students were reluctant to miss.

Additional difficulties that emerged from discussions with students, the program coordinator and the school staff included the following aspects:

- The limited number of courses offered by the Open University, due to the requirement of having at least 15 students per course. In some cases, such as in chemistry, this was compromised and the course opened for 7 students.
- A difficulty to see how students can complete an academic degree in four years during their high school studies.
- A lower perceived status of the Open University due to the fact that it has a general open policy of admission.
- A conflict with school over missing out on courses that the students want to matriculate in, which are taught on the day they attend the Open University program. There are discussions with school principals, as well as with officials in the Ministry of Education in order to deal with this issue.

One way of dealing with these difficulties was to clarify the course of study that the Open University offers these students. In line with student's desire know more about the course of study in various subject areas and how they can complete a BA in four years of study, it was decided to design a special course of study for them in computers, life sciences and the social sciences that will allow them to complete a BA while they are still in high school. Information about these courses of study was provided in a special information bulletin, as well as in meetings with students and their parents before the beginning of the academic year of 2001-2002.

What were the outcomes of this acceleration program in its first year of operation? The great majority of the students who attended the program completed the courses successfully. Some students even took summer courses in the Open University on their own initiative. The group's average final grades in various course ranged from 76 to 87. It is important to note that 13 students were eligible to receive honorary mentions for excellence, which are quite rare for the general student body. Three of them were on the President's list, which requires that a student attend at least three courses and receive an average grade of 95% or above. This entitles them to a scholarship. Ten of them were eligible to be on the Dean's list, which requires that a student receive an average grade of 90%-95%. Although it is hard to predict how many students will actually complete their BA while in high school, in group interviews, students express the view that one of the greatest benefits of this acceleration program is that they get a taste of what it's like to study an academic subject on a university level. Moreover, their academic self image and sense of competency is enhanced by this experience. Furthermore, they increase their circle of friends considerably, forming friendships with peers who share similar interests and capabilities in various talent areas.

3. Enrichment in Interdisciplinary Fields

Life is not a disciplinary affair. Real problems cannot be classified clearly to scientific, economic, musical or artistic problems. Real problems are an integration of all of various components from different disciplines (8). Thus, scientists may need knowledge and skills from different fields of science, as well as a sense of aesthetics and an understanding of the economic and ethical implications of their inventions. How can we enhance this interdisciplinary approach among students with extraordinary potential to excel in the sciences? One way is to provide them with real life experiences which require an interdisciplinary approach and enhance interdisciplinary thinking. An example of such a series of experiences in the sciences is the study of robotics.

The study of robotics enables students to integrate skills, knowledge and insights in a variety of fields, such as computers, physics, mathematics, mechanics, electronics, aesthetics, design and ethics in a hands-on, experiential manner. Moreover, it requires them to cooperate in team work to produce a robot, thus enhancing their social skills. Robotics can be studied on a continuum ranging from a basic level in the elementary school to a very sophisticated level in the university. Therefore, students can engage in it in varying levels of sophistication, in line with their capabilities and interests.

How is the study of robotics implemented in programs for gifted students in Israel? 6th graders attending the enrichment magnet center in Herzeliya (a city in the central part of Israel) study robotics in a one year long course that focuses on building robots with 5 groups of students. Each group defines, at first, what kind of actions (within certain limits) it would like the robot to perform. Each group proceeds to discuss the various aspects that are involved in the process of building the robot, such as computer programming, electronics, mechanics, and design. Students then divide into teams that work on these aspects according to interest and share their knowledge with one another. At the end of the year, the robots are displayed be for students, staff and parents and a committee awards a prize to the most sophisticated robot.

Student feedback on the course, as well as interviews with the coordinator of the program and with the school principal, under whose auspices the center operates, indicated that these gifted students regard robotics as an interesting challenge. They express much enthusiasm to engage in the project of building a robot, together with an enhanced sense of responsibility and commitment. However, they need expert support during the process of working on the robot, as well as guidance to develop independent work habits in their teams.

In another enrichment magnet center situated in Oranim college in the north part of Israel, gifted junior high school students study robotics in two year courses. Beginning robotics course operates in a similar manner to the course in Herzeliya that was described above. Students build simple robots, learning about various principles in electronics, circuits, control systems, algorithms and computer programming that are used in the process. Then they divide into groups that build robots that can fulfill certain functions. In each group, students are assigned certain roles. These roles include:

- Group manager who plans the tasks that have to be performed, determines the time schedules and is responsible for making sure that each member fulfills his/her task.
- Information specialist who collects information that the group needs from various sources, such as internet sites, libraries, teachers, etc…
- Building and parts specialist who is in charge of choosing the parts, building them and making electric connections.
- Programming and algorithm specialist who is responsible for writing the operating program for the robot according to the group's specifications.
- Communications specialist who is in charge of loading the operating program on the robot and making it work.

Each role is essential for the success of the project. Students discuss these roles and reach a group consensus who will fulfill each role according to interest, knowledge, or lottery. At the end of the year, the group that developed the most successful robot is awarded a prize.

Advanced robotics is studied in a year long course of eighth and ninth graders. Students are divided into groups of two to three students. In the first phase of the course, students build models of electronic robots. They assemble the mechanical systems of the robots and control cards. They also perform experiments in guiding the robots' movement. In the second phase, students program the control card of the robots, enabling them to perform complex tasks, such as going fast through a maze, utilizing various sensory systems.

The regional supervisor of robotics in the Ministry of Education, who visited the program, attested that although he was quite skeptical about the ability of the students to handle such a complex subject matter when he reviewed the program before the academic school year, his visit laid his doubts to rest. As he talked with students and observed their work, he saw that students are very enthusiastic about their work in this field. Moreover, based on his observation of actual lessons and review of their work, he concluded that students demonstrate great capability in dealing with the challenging tasks before them.

above and beyond their grade levels. They use the most sophisticated software programs utilized in high tech companies. They deal with content matter that is intended for students specializing in electronics, physics and computer programming at the end of high school, and they proceed at a much faster pace than is expected. Therefore, they are able to integrate knowledge and skills from various content areas and utilize them successfully to produce sophisticated products.

4. Science and Technology in the Service of the Community

One of the major challenges of gifted programs in Israel is to enhance social interest and commitment to society as an integral part of the curriculum in gifted programs. This challenge is in line with the goal of helping gifted individuals realize their potential, while becoming productive members of our society. In order to meet this challenge, the Department for Gifted Students encourages teachers and administrators to develop various projects involving long term commitment to the community. Moreover, programs are urged to integrate service to the community into the study of specific subject areas, such as science and technology. Some of the most innovative approaches to this serious challenge include The Country of Water Streams project, the Young Entrepreneurs project and the I Can Also Do project

The Country of Water Streams Project. This project was developed with the Ministry for the Quality of the Environment. The aims of the project were to monitor the quality of the air and the water in various water sources in Israel. Gifted junior high school students from several enrichment magnet centers around the country engaged in this long term project of monitoring the quality of the air and the water in streams and rivers in their area. Students from different centers organized, analyzed and exchanged information via the internet. The results of the monitoring were conveyed to the Ministry for the quality of the Environment, which used it for policy planning. Periodically, meetings of all the students that participated in the project were held to share information and study together about ecology and biology. The benefits of this project are threefold:

- Students understood the phenomenon that they studied in a more meaningful way.
- Students felt that they were helping to solve a real problem and contributing important information to help make policy decisions.
- Students connected with gifted peers who shared the same interests from different centers.

The Young Entrepreneurs Project. This project simulates the founding of a company that analyzes real problems, capitalizes on a solution and turns it into an actual product, which is marketed.. The objective here is to go through the actual process of establishing a company, thinking about real problems, analyzing the problems, coming up with innovative solutions, producing the solution and marketing it. The phases of work in this project include:

a. Establishing a company with a CEO (Chief Executive Officer), CFO (Chief Financial Officer), CTO (Chief Technology Officer), marketing director, etc…
b. Getting funding from various self generated sources, such as tutoring other students, operating an activity center for young children during vacations, washing cars, etc…
c. Brainstorming about various problems.
d. Analyzing the problems
e. Coming up with innovative solutions to the problems.

f. Conducting market surveys to assess whether the solutions are marketable.
g. Assessing costs for developing, manufacturing and marketing products.
h. Deciding which product to focus on.
i. Producing the product.
j. Marketing the product.

The Young Entrepreneurs project has been operating successfully in self contained classes for gifted 9th graders in Shmuel Ha-Nagid junior high school in Herzeliya and in Ohel Shem high school in Ramat Gan (both schools located in the central part of Israel). One of the most heralded products was developed in the school year of 1998-1999 in the junior high school in Herzeliya. The students established a company called 'idea', which had a mission to produce and market various means to prevent car accidents. The need for such products stems from the fact that in 1997, there were 25,491 car accidents. 3825 of these accidents were caused by cars not keeping a safe distance from one another. The available means to help maintain a safe breaking distance were shown to be problematic for various reasons. The sticker "keep a distance" is too general. The method of counting seconds depends on the drivers' skills and is ineffective at night. Laser devices to measure distances are too expensive and therefore, cost ineffective.

After analyzing the problem and brainstorming about various simple, yet effective solutions, the company came up with the idea of designing a car StiCare (a sticker that cares), printed with the numerals 5, 7, 9 according to the legal speed limits in Israel (50, 70 and 90 kilometers an hour), in different sizes. When a driver drives 50 kilometers an hour and sees the numeral 5 clearly on the StiCare of the car in front of his car, he has to increase the distance from the car until he sees the number fuzzily. The same principle applies for the numerals 7 and 9 in relation to the speed limits of 70 and 90 kilometers per hours, respectively. The sizes of the numerals were determined after consulting with an ophthalmologist, an optometrist, and a physicist and performing careful calculations about the distances needed to see the numerals with an eye-sight of 6/12 (which is the limit permitted by law for driving without corrective lenses). The final product was produced in a professional printing press and marketed in car exhibits, in Israeli product fairs and by selling it door to door. StiCares were also sold to several companies with service cars, such as mineral water companies. The company made headlines in various papers and magazines, as well as on TV. The student owners were invited to present the product and the company in a major economic conference in Israel, as well as to the Minister of Transportation. The student owners of the company decided to donate the profits of the company to a rehabilitation center that specializes in working with people who were injured in car accidents. Last, but not least, the StiCare won first prize in the Israeli Young Entrepreneurs competition of 1999. Moreover, It represented Israel in the international Young Entrepreneurs competition in Ireland and won first prize. It won second prize in a similar competition in Sweden.

A recently developed product that high school students at Ohel Shem high school in Ramat Gan devised according to the same process is a remote control device that indicates by color change or light flicker whether the house door is locked. The miniature device is attached to the regular house key. It flickers or changes color within the first ten minutes after leaving the house. The company that the students established to develop this product in the academic school year of 2001-2002 is headed by a CEO who is a gifted student and manned by students from the gifted classes in the school, as well as other students from in the school. The company conducted a market survey to determine the need for such a product before producing it. The results of this survey demonstrated that 85% of the respondents expressed a need for such a device, attesting to the fact that they often ask themselves whether they locked their house door. This product won first prize in the Israeli Young Entrepreneurs competition for 2002. The students will represent Israel in the international Young Entrepreneurs competition, which will be held in England.

This type of project enables students to develop skills that are essential for success in the real world, such as team work, leadership skills, persistence, personal initiative, and effective problem solving, communication and presentation skills, decision making skills, and business skills, such as writing a business plan, negotiating and marketing

I Can Also Do Project. In the academic year of 2000-2001, the Division of Science and Technology in the Ministry of Education initiated a competition for developing models or prototypes of products that provide solutions for people with various disabilities. The aims of this competition include:

- Encouraging young people to cope with an interdisciplinary topic that integrates science and technology aspects with social and human concerns.
- Providing an experiential learning opportunity to high school students.
- Transforming principles and ideas in science and technology into actual products.
- Providing an opportunity to develop a practical solution to a real need.

Gifted high school students from Ohel Shem high school in Ramat Gan participated in the competition under the auspices of the local science, technology and visual arts center. Students met with people with various disabilities, such as deafness, blindness and paralysis. They heard about their modes of coping with daily challenges and discussed their special needs with them. In line with the needs of their disabled friends, students proceeded to design various models and prototypes of products to help them cope. Students received help from the school staff and from specialists who devise models for laboratories and for medical purposes. The products that the students developed include a distance detector device for the blind, working via sensory systems; a towel that operates with a motor and hot air that is intended for people who are unable to use their arms; and an alarm clock that vibrates that is intended for deaf people.

What is the value of such projects? These types of projects enable students to develop their abilities to deal with real complex problems, utilizing critical, divergent, interdisciplinary thinking in applying scientific and technological principles to produce knowledge and manufacture products and solutions to these real problems. All of these capabilities enhance a sense of competency and increase self confidence in one's capabilities. Moreover, with the emphasis on service for the community, these types of projects enhance the commitment of students to develop products that utilize our knowledge to contribute to our society and make our lives better.

In the words of the student who developed the automatic towel, Yael Viesel, the encounter with people who are unable to use their arms was extremely important. "I experienced what it's like to go through their day and learned from them about life with their disability. The meetings with them contributed very much, on the one hand, to the development and the improvement of the automatic towel. On the other hand, they contributed toward my understanding of the wisdom that is hidden in the body of a human being and toward my comprehension of the victory of the human spirit."

References

[1] R. Zorman, and S. Rachmel, Guidelines for a Special Curriculum for Gifted Students in Enrichment Magnet Centers. The Ministry of Education and Culture and the Szold Institute, Jerusalem, 1995 (in Hebrew).
[2] R. Zorman and S. Rachmel, Principles for Developing a Special Curriculum for Gifted Students, The Ministry of Education and The Szold Institute, Jerusalem (in press in Hebrew).
[3] L.K. Silverman, Helping Gifted Girls Reach Their Potential, Roeper Review, 13(3) (1991) 122-123.
[4] J.C. Stanley, An Academic Model for Educating the Mathematically Gifted, Gifted child Quarterly, 35(1) (1991) 36-41.
[5] T.M. Richardson and C.P. Benbow, Long-Term effects of Acceleration on the Social-Emotional Adjustment of Mathematically Precocious Youths, Journal of Educational Psychology, 82(3) (1990) 464-470.
[6] M.A. Swiatek and C.P. Benbow, Ten-year longitudinal follow-up of ability-matched accelerated and unaccelerated gifted students. Journal of Educational Psychology, 83(40), 528-538. 1991.
[7] J.C. Charlton, D.M. Marloff and J.C. Stanley, Follow-up Insights on Rapid Educational Acceleration, Roeper Review, 17(2) (1994)
[8] R.S. Root-Bernstein, Tools of thought: Designing An Integrated Curriculum for Lifelong Learners. Roeper Review, 10(1), (1987) 17-21.

Adolescent Pathways to Eminence in Science: Lessons from the Music Conservatory

Rena F. SUBOTNIK
American Psychological Foundation, Center for Gifted Education Policy
750 First St. NE, Washington DC 20002-4242 USA

Abstract. As a world-renowned conservatory with a long history of preparing elite musicians, the philosophies and practices of Juilliard raise important questions regarding the preparation of elite talent in other domains. Intellectually gifted college-age students of comparable promise and career ambition as those found at Juilliard enter our universities with few opportunities for individualized instruction, cutting-edge research positions, or career advice. The purposes of this study were to explore the critical variables that contribute to the transformation of extraordinary talent in music into professional artistry and to offer insights into restructuring the way that we meet the needs of academically gifted youth based on the success of the conservatory system. Several suggestions for implementation in the world of academia include: (1) employing some form of audition for admission, (2) viewing each student as a unique challenge, with his or her own set of skills, talents, personality, and intellectual acuity and interests, (3) providing students with regular opportunities for public demonstration of learned skills and creative work, and (4) broadcasting the talents and creative productivity of the faculty and encouraging students to apply to programs based on that information.

1. Talent development in science: A comparison leads to the conservatory

In 1983, I began a 13-year longitudinal study of talented young scientists (1-4). Each of the participants was a winner of America's most prestigious high school science award: the Westinghouse Science Talent Search (now called Intel Science Talent Search). In order to win this award, one had to submit a technical paper describing an original mathematics, life or physical science, or quantitatively based social science investigation, usually under the guidance of an experienced researcher. The judges included Nobel laureates, high-ranking scholars at the National Institutes for Health, the National Science Foundation, and major research universities.

In the course of preparing their papers, the Talent Search winners enjoyed significant participation in the conduct of real science. Although 95% aspired to research or applied science careers, they chose which university to attend based on general prestige rather than on specific faculty members with whom they might study. By the end of their second year in university, two-thirds of the women had dropped their mathematics or science majors, and many of the men were disappointed with their training and preparation. They had been shuttled into classes with several hundred students and received little or no individual attention. If they managed to arrange some affiliation with a science laboratory at the university, they were assigned menial tasks. Most of those who survived the first two years at university were able to enjoy relationships with mentors, more cutting edge coursework, and opportunities to contribute significantly in laboratory efforts. Although these brilliant young adults eventually achieved career success in an array of fields, I was dismayed at how blindly they selected an undergraduate institution and how cavalierly our finest universities addressed such outstanding talent at its peak of enthusiasm.

In 1996, as I began my last data collection point in the Westinghouse study, Franz Monks from the University of Nijmegen, told me about a fabulously talented young musician he met in his clinic. He asked me to make some inquiries about this student's possible enrollment at The Juilliard School. The Director of Admissions at Juilliard, Mary Gray, graciously answered my questions. In the course of a freewheeling conversation, we discussed my interviews with Midori and Vladimir Feltsman, two internationally renowned artists as part of a series entitled, "Conversations with Masters in the Arts and Sciences." Midori had been a student at Juilliard beginning in early adolescence. Feltsman entered a special full time music school in Moscow at age 6 and completed his elementary and secondary studies there. Both were constantly challenged by teachers and the performance world to surpass the levels of proficiency they had achieved in adolescence. This confluence of experience – the Midori and Feltsman interviews and my visit to The Juilliard School – led me to propose to the Juilliard administration a study of how the pre-college program (5), and the actual conservatory, transform elite musicians into professional artists.

Intellectually gifted college-age students of comparable promise and career ambition as those found at Juilliard enter our universities with few opportunities for individualized instruction, cutting-edge research positions, or career advice. At Juilliard, studio teachers and students have close one-on-one relationships. There is readily available an abundance of performance opportunities and gifted peers, and scheduled access to explicit, practical information required for the fulfillment of talent. The objective of this study is to offer insights into restructuring the way that we meet the needs of academically gifted youth based on the success of the conservatory system.

2. Does the Conservatory Hold Some Lessons for Universities?

Mastery of the repertoire in classical music performance is highly sequential and steeped in rich tradition. The relative orderliness of the field makes it an ideal platform from which to view the development of talent, from its beginnings in early childhood through the nurturing of professional careers. The most important relationship throughout the developmental process is with one's private (or studio) teacher, and most teachers who work with advanced students carry a proud lineage of descent from earlier generations of teachers, performers, and composers (5-10). In science, Nobel laureates also display a mentor-protege pattern that mirrors the one found in music (11). Doctoral students in academe tend to know something about the work of their prospective professors, if not their lineage. In music, reputation is key, even when choosing a teacher for a pre-adolescent. A chance to work with teachers of distinct lineage is what draws many students to a conservatory.

One role that a studio teacher plays for some talented musicians and not others is career advisor. That practical or tacit knowledge is instrumental to career success in any field (12), yet leaving that responsibility solely to studio teachers can be haphazard (13). Through a series of seminars affectionately called "Reality 101," Juilliard offers its students exposure to many potential sources of professional and practical wisdom.

The conservatory offers access to talented peers who approach, match, or even surpass a student's abilities and ambitions, yet share the passion and commitment needed for sustained effort (14,15). Young musicians deal with pressures of competition, which contribute to or detract from their growth in artistry or scholarship (16). In the end, the student, with the help of his or her teachers and peers, must forge a unique identity as an artist and capitalize on whatever performance opportunities are available.

3. A Study Conducted at America's Premiere Music Conservatory

Thirty-four Juilliard faculty and administrators were interviewed in person for this study. Although a little more than 20% of the staff that works in the Music Division participated, the main instrument and voice departments and all levels of relevant administration are represented. Juilliard's Music Division serves only 320 undergraduates, so the full-time staff and faculty are often called upon to play many roles. Most of the administrators teach courses or instruct individual students in their own studios. Half of the non-studio or classroom teachers (in liberal arts, theory, ear training, etc.) hold some kind of administrative position within a department or else serve as coaches to student ensembles or performance groups.

3.1. Defining elite talent

A successful audition is the central criterion of the admissions process, and lasts anywhere from 10 to 30 minutes. Approximately 90% of those applying for admission to Juilliard are rejected since there may only be one or two openings for a new student in each department. The challenge of the admissions process is to sort out those who would benefit most from the program from among a large pool of talented applicants.

A team made up of each department's studio teachers sits in the auditions and rates candidates on a list of variables including "chops" or technique (command of the instrument), rhythm, intonation, sound, and style. There are two open questions on the audition form in addition to a space for general comments: *Should this student be accepted? If so, would you take this student in your studio?* Applicants who elicit a more subjective quality like excitement or musicality (how one communicates, the influence of style and emotion on technique) are more likely to succeed, because all applicants are expected to demonstrate high level mastery of the skills listed on the audition grid.

When the varied tastes and values held by each faculty member are in consensus about an applicant, they are viewed as "destined for greatness." However, if there is sufficient space in the program to bring in the next level of candidates, differences in values and tastes held by faculty judges may result in the admission of candidates who are sufficiently pleasing to all, yet not particularly exciting to any.

According to our interviewees, the audition process works well at unveiling "God-given talent" developed by way of intensive focus and hard work. One studio teacher summarized this perspective by saying, "I think the biggest most important part of it is innate. You can recognize it, squelch it, encourage it, develop it, but you can't put it in." Although the results of the audition process are considered satisfactory, some important factors cannot be addressed using a static assessment process. Some departments have introduced a second, dynamic layer of assessment, including an interview and/or a sample lesson to evaluate the "teachability," musicianship, or physical memory of the candidates. For example, if the high quality of an audition is really a result of focused practice with a limited repertoire of skills and material, the student may not be able to extend those skills and abilities as effectively as other students with equal audition ratings. Teachers seek students who can translate given instruction and advice into their musical performance, and who can learn new material quickly by dint of excellent physical memory.

In the final stages of the talent development process, personality factors tend to outweigh all other variables. Those who are most likely to fulfill their dreams of career success capitalize on charisma and attractive appearance, and apply those qualities to opportunities that come their way According to the interviewees greatness results from a *hunger* to express oneself through the medium of musical performance. Measuring and quantifying such poorly defined variables as charisma and fortitude remains unfinished business; yet, Juilliard has revealed for us a pattern that may very well be mirrored in the more academic environments where we conduct our work.

3.2. Studio teacher and student relationships: The basics of talent development

A musician's instructional lineage is taken seriously, demonstrating the veneration with which studio teachers are held in the classical music world. Although the only information provided to audition panels is the name of the candidate's hometown, some applicants mention their teacher's name as part of their brief greeting. Even when the name of the teacher is hidden, his or her unique stamp is often evident to the panel. They can figure out the name of the teacher based on the hometown and the quality of the candidate's preparation. In many cases, these teachers were former Juilliard students, "grandchildren" of the department. The close-knit nature of this world is also revealed by the fact that over 40% of the faculty and administration of the Music Division had some training at Juilliard, either as an undergraduate or graduate student.

Studio teachers are not on full-time contracts. Instead, they are paid according to their prominence and/or the number of students in their Juilliard studio. Each student has to pass a jury examination at the end of the year, judged by all the members of the department. How well a teacher's students do on the jury examination may affect the esteem in which a teacher is held. When students apply, they can indicate a first, second, and third choice studio to be admitted to, or else leave the space blank. A few students will turn down admission to Juilliard if their first choice of teacher does not prevail. According to the admissions office, about 70% of students make their preferences for a studio teacher known; however, the proportion of pre-audition trial lessons that take place varies according to department.

In the piano and violin departments, where competition for open slots is the most severe, few of the students come in without having "checked out" at least one faculty member. In other departments the proportion of pre-audition interactions may be as small as 20%, especially in voice, where students tend to discover and develop their abilities later than violin and piano students, who apply with at least seven or eight years of serious preparation under their belts. Because there are so many variables involved, including personality, values, and teaching and learning style, sophisticated applicants to Juilliard pre-audition with various faculty members at summer festivals or in New York. And a few of the faculty members arrange to meet individually with prospective students before committing to take them on, to see if enough chemistry is there to work productively together.

The nature of the student-teacher relationship can vary in the degree to which emotional support is given or needed. Although we might idealize the notion of a warm and caring relationship, not every student needs or seeks that at this point in his or her career trajectory. In the course of discussing the nature of the teacher-student relationship, two main points emerged. According to our interviewees, no student needs to be subjected to browbeating. Although most high quality teachers say they do not subscribe to the "break down and build up approach," this *maestro* model (17) has been successful in generating world-famous artists. Some students are prepared to undergo whatever is necessary to learn what they need to advance. Whether the maestro approach is singularly more successful than any others remains to be seen, and with the growing variation in teaching style, a better match can be made to accommodate a wider array of student learning styles.

There is no Juilliard philosophy when it comes to instruction. Nor are there professional development seminars for studio faculty. Studio teachers tend to view each student as a puzzle to be analyzed and developed, and, consequently, many strategies are employed, particularly when the performance styles of student and teacher are not compatible. The possibility that students will stop applying to their studio as well as the highly visible success rate of current students in their jury examinations provides accountability for teacher quality.

3.3. Curriculum matters

Once a student has been admitted, technique and exposure to an increasingly challenging repertoire continue to be the centerpieces of the curriculum. In the process, emphasis is placed on the unique qualities of each student, with the goal of developing in them a profile of distinctive strengths. Advanced students are expected to develop their judgment and taste by addressing situations faced by every performer, such as differentiating how one plays as a soloist as opposed to how one plays as a member of an ensemble or an orchestra. How one presents oneself in a public forum – including dress, verbal communication, receiving compliments or criticisms, or recovering from performance errors, requires conscious attention, and according to our interviewees, are better not left to luck.

Students are encouraged to expand their horizons in the humanities through the curriculum and through their friendships with members of the other departments and divisions of the school. Many view this stretching as the path to artistry. There are more practical reasons for offering a broad curriculum. Students must learn how to speak and write about the music they perform or compose in the course of interviews and program introductions. In addition, the realities of the performing arts world make it useful to know something about teaching and advocating for the arts.

Another relatively new component of the curriculum is the focus on practical knowledge in attaining a successful career in music. Each of the departments conveys this information in its own way. Students learn how to write resumes, how to conduct themselves in auditions, how to dress, how to organize an interesting performance program, and also to consider positions as accompanists, critics, etc. The most practical creative skill that Juilliard students will implement as part of their career is teaching, and far more attention is being paid by studio and classroom teachers than in the past to having students think metacognitively about how they might help another student solve the same musical problem.

Over the course of the baccalaureate program, particularly in seminars and elective courses designed to address career matters, students are encouraged to find psychological balance. They need to have a thick skin in order to tolerate the frustrations of rejection in such a highly competitive performance world. At the same time, they must be able to show composure and be a good colleague. Students are reminded that their classmates will be future ensemble or orchestra colleagues. They may be in positions to recommend hiring you, and they may also serve as competitors. In a small community, it is best neither to hold grudges nor to be the subject of them. These lessons are discussed explicitly in departmental seminars.

4. Applications of the Conservatory Model to the Education of Elite Talent in the Academic Disciplines

As a world-renowned conservatory with a long history of preparing elite musicians, the philosophies and practices of Juilliard raise important questions regarding the preparation of elite talent in other domains. The purpose of this study was to explore the critical variables that contribute to the transformation of extraordinary talent in music into professional artistry. It follows in the footsteps of the explorations conducted in the sciences with Westinghouse Science Talent Search winners (4), with high-IQ children grown up, and with the Juilliard Pre-College Program (5). In each case, an argument is made for more rigorous and individualized teaching and learning based on extraordinary strengths and deep interests.

The conservatory model would be inappropriate for most undergraduate students. Only a select few will have committed themselves to a particular career path upon entry and been involved in preparing for that career by investing a large proportion of their adolescence to furthering these pursuits. *The proposed adaptations are offered for working with university students who meet the following two criteria: (1) elite level talent judged to be equivalent to the talent exhibited by Juilliard students, (2) a desire to pursue an academic discipline deeply, possibly as a life's work. I would argue that patterned after the success of the conservatory with equally gifted students of the same age, academically gifted students should receive doctoral type instruction during their early university years.*

Some suggestions for implementation follow:

• *Employ some form of audition for purposes of admission.*

Auditions have advantages and disadvantages. Their primary advantage is that they are content valid. Candidates are asked to display skills and talents directly related to the program for which they are applying. Second, there are no secrets about the preparation that is involved, since the requirements are made explicit. Most teachers who work with advanced students would be preparing students for this repertoire in the form of recitals and competitions. Consequently there are no surprises, and no real way to cheat.

Auditions also have drawbacks. They are certainly subjective. Candidates can be disregarded if their appearance or manner seem off-putting. Biases against certain groups can also come to the fore with little accountability for the decisions made. Second, once the top candidates are selected, open slots may be filled with those who are sufficiently pleasing to most but not necessarily exciting to any.

Juilliard has dealt with these drawbacks in the following ways: one is to deliver clear messages from the administration that a supremely talented yet diverse student body is welcome and desired. The other is to limit the number of students that are admitted. Only the most gifted will be invited. Any available slots that remain in a department are filled with a qualified graduate student.

Students who are mathematically or scientifically gifted, who have been participating in research projects, summer institutes, and camps, could be invited to "audition" with members of those departments at various universities, rather than or in addition to interviews conducted with the admissions staff. Modeled after the Intel Talent Search, students who are extraordinarily talented in academics could be admitted to an institution on the basis of a two-step process. First, they would submit samples of their work to the faculty in the discipline they hope to pursue. Second, they would provide a brief oral presentation to the faculty addressing the research problems they would like to tackle. This approach is used regularly with doctoral students and is especially helpful in matching students with professors who are working in related areas. In evaluating a student's submitted work and presentation, it is important to consider what resources are available in the program to fortify student weaknesses and develop unique strengths.

• *Each student is viewed as a unique challenge, with his or her own set profile of skills, talents, personality, and intellectual acuity and interests.*

Too much energy, emotion, and time can be wasted on competition with others within a teacher's studio or a professor's laboratory. Comparisons are inevitable, but self-flagellation is not. Two aspects of the Juilliard program that help to alleviate this difficult situation include individualizing instruction in the studio and offering seminars geared to inculcating practical intelligence. The studio teachers interviewed for this study say they love to teach. They view each student as a challenge, and they are held accountable for their students' success by way of juries, concerto competitions, job placements, and the number of new students that wish to join their studio. In order for their students to be successful in the deeply competitive music performance world, they are motivated to help nurture the artistry of their students.

Professional critics, managers, tax lawyers, and performers meet with students in each department by way of explicit practical knowledge seminars. Students are reminded that their classmates are to be treasured as current and future friends, supporters, and teachers. They may also someday be a source of employment. Learning to be gracious at all times and under all circumstances is a goal that students are asked to consider.

In the academic world, individualization would be welcome to entering university students. The elite group of Westinghouse Science Talent Search winners that I studied encountered large and anonymous classes in mathematics and science at their elite universities of choice. By the end of the second year, one-third had left science and mathematics. Some were attracted by other disciplines, and have pursued rewarding careers in those areas. Others might have left because they were not able to keep up with the material. Yet, in order to win the Westinghouse Science Talent Search, they had spent their high school summers and afternoons in close contact with professors and graduate students, often on the frontiers of a science sub-specialty. Once they got to college, a distinct number of winners were turned off by the inaccessibility of meaningful laboratory opportunities until they were in their third or fourth year, or even graduate students.

As for the practical knowledge gained from the explicit seminars on career related topics, Sternberg *et. al.* (12) has provided ample support for how this knowledge contributes to the success of individuals in different fields. Certainly the socialization process could be made more consistently available to gifted students. It is especially healthy for students to understand the growing role played by personality, charisma, and drive in creating stars, not only at Juilliard but also in every field. Specific practice in interviewing, making presentations, networking, teamwork, problem selection, solution selection, and time management would be invaluable to young scholars. Too often in the university setting this information is provided haphazardly by mentors. Access to this information is too important to career success to be left to chance.

- *Regular opportunities for public demonstration of learned skills and creative work should be available.*

Young talented scholars should be able to display their skills publicly in a variety of venues. There is no reason why institutional research seminars and roundtables should be solely in the purview of graduate students and post-docs. Every opportunity to speak publicly about one's work helps to clarify one's own thinking and to inform others about new and exciting ideas. Student stars should be encouraged to make co-authored or even single authored conference presentations and follow up with publication.

Annual juries are one way that student skills are displayed at the conservatory. The entire faculty from the department attends these examinations and gives a grade to the student. Novice scholars could benefit from an annual jury of their skills and ideas evaluated by all the members of the department. The institution would also benefit by the cross-pollination that is bound to result from hearing what is developing in the labs and the classrooms within a department. An even better idea, particularly in the academic realm, would be to provide written feedback on the presentation. Students who have poor juries for two years in a row, who cannot keep up even after receiving coaching and assistance, disrupt the learning of others, or show a lack of commitment should be counseled out of the program. This decision need not be nearly as traumatic as it is for a musician who has invested years of work to the exclusion of other pursuits. Stepping back into a broader liberal arts program might be more suitable for an academically gifted student who is not yet ready to focus on one area in such depth.

Focusing on one area should not preclude creative and meaningful interactions with talented students and their professors in related disciplines. The enrichment and insights that can be gained from interdisciplinary projects parallel the path musicians make to achieve artistry. The path to transformational scholarship will be enhanced by such exposure as well.

- *Broadcast the talents and creative productivity of the faculty and encourage students to apply to programs based on that information.*

Our universities need to promote the talents of their faculty to undergraduates considering their programs. Students should be coming to higher education with a sophisticated knowledge of their professors' work. University teachers appear in public forums, and their work is available in libraries and on the web. I have often wondered why there were so few guides and websites that offer background information about faculty to prospective undergraduate students who have clear career goals. The Internet provides an opportunity for highly talented mathematics and science students to read the work published by various potential faculty mentors, and to contact other students who have interacted with them in the labs. Academic faculty share intriguing lineages just like their conservatory peers; they are also entitled to the veneration that accompanies the special relationship between student and teacher in the performing arts world.

In the course of this research, I was especially fascinated with the terminology tagging the different stages of talent development in the music world: one moved from being an instrumentalist to being a *musician*. If one's performance and contributions were truly transformational, then one could be called an *artist*. In the academic world the parallel might go from *student*, to *academic*, to *scholar*. The goal of this study was to highlight some features of the process of talent development in the performing arts so that we might consider adapting them to our settings. After my immersion in the world of Juilliard, I will never again hear a performance without thinking of the effort, time, and passion that went into it. Nor will I advise a gifted student without remembering the lessons learned from the conservatory.

References

[1] R.F. Subotnik and K.D. Arnold, Passing through the gates: Career establishment of talented women scientists. *Roeper Review*, **18** (1995) 55-61.

[2] R.F. Subotnik, R. Duschl and E. Selmon, Retention and attrition of science talent: A longitudinal study of Westinghouse Science Talent Search winners. *International Journal of Science Education*, **15** (1993) 61-72.

[3] R.F. Subotnik, K. Maurer and C.L. Steiner, Tracking the next generation of the scientific elite. *Journal of Secondary Gifted Education*, in press

[4] R.F. Subotnik and C.L. Steiner, Adult manifestations of adolescent talent in science: A longitudinal study of 1983 Westinghouse Science Talent Search Winners. In: R.F. Subotnik and K.D. Arnold (Eds.) *Beyond Terman: Contemporary longitudinal studies of giftedness and talent*, Norwood, NJ: Ablex, 1994, pp. 52-76.

[5] R.F. Subotnik, The Juilliard model for developing young adolescent performers: An educational prototype. In C.F. M. van Lieshout and P.G. Heymans (Eds.) *Developing talent across the lifespan*. Hove, UK: Psychology Press, 2000, pp. 249-276.

[6] J. Haroutounian, The delights and dilemmas of the musically talented teenager. *Journal of Secondary Gifted Education*. **12** (2000) 3-16.

[7] R.S. Persson, Studying with a musical maestro: A case study of commonsense teaching in artistic training. *Creativity Research Journal*, **9** (1996) 33-46.

[8] B.L. Sand, *Teaching genius: Dorothy DeLay and the making of a musician*. Portland, OR: Amadeus, 2000.

[9] L. Sosniak, Phases of learning. In B.S. Bloom (Ed.) *Developing talent in young people*. New York: Ballentine, 1985, pp. 409-438.

[10] Shuter-Dyson, R. (1985). Musical giftedness. In J. Freeman (Ed.) *The psychology of gifted children* (pp. 159-183). Chichester, UK: JohnWiley.

[11] H. Zuckerman. *Scientific elite: Nobel laureates in the United States* (2nd Ed.). New Brunswick, NJ: Transaction, 1996.

[12] R.J. Sternberg, G.B. Forsythe et al.. *Practical intelligence*. New York: Cambridge University Press, 2000.

[13] C.P. Schmidt and M.L. Andrews, Case study of a first year university voice major: A multidisciplinary perspective. *Psychology of Music*, **24** (1996) 237-243.

[14] B.S. Bloom, Generalizations about talent development. In B.S. Bloom (Ed.). *Developing talent in young people*. New York: Ballentine, 1985, pp. 507-549.

[15] R.F. Subotnik and L.J. Coleman, Establishing the foundations for a talent development school: Applying principles to creating an ideal. *Journal for the Education of the Gifted*, **20** (1996) 175-189.

[16] E. Seymour and N.M. Hewitt, *Talking about leaving: Factors contributing to high attrition rates among science, mathematics, and engineering undergraduate majors*. Boulder, CO: Bureau of Sociological Research, University of Colorado, 1994.

Author Note

An expanded version: Subotnik, R.F. (in press). Transforming elite level musicians into professional artists: A view of the talent development process at the Julliard School. In L. Shavina and M. Ferrari (Eds.) *Beyond knowledge: Extra cognitive facets in developing high ability*. Mahwah, NJ: Erlbaum.

Concluding Remarks and Perspectives

Péter CSERMELY
Hungarian Student Research Foundation
H-1149 Budapest, Dongó str. 8., Hungary

Science education is an important element of the recruitment of further generations for scientific research. In this complex process a key point is the science education of high school students, who are in a very susceptible age to ask clear questions about the world around them, and to seek answers in a methodological way, as science does. This is the age of self-test, where the adolescent tries his strength and capabilities. Scientific research provides a unique and unparalleled opportunity for outstanding achievements. The hierarchy-free atmosphere of a good scientific group gives the talented high school student a long-sought freedom and a unique opportunity to break from the original social and economical circumstances of the family. Organisation of these students gives a lot of friends for these young fellows, who are often considered "odd" and "funny" in a regular school. Moreover, research training makes the social circles surrounding these students (schoolmates, family, relatives, etc.) understand science and breaks the alienation from scientific research in a significant part of the society. All these benefits would be really a treasure in the conflict-loaded, differentiated societies of Central-Eastern Europe, where after the initial social mobility the channels, where young members of the society may find an opportunity to change their social status were significantly narrowed.

The workshop spurred a great interest in the 23 participating NATO and partner countries and gave a comprehensive survey of existing, highly successful examples of scientific research training in Europe, in the USA and in Israel. The concentrated introduction of the best practices provided a unique opportunity to learn successful elements from other initiatives as well as to implement these techniques to other Central-Eastern European (mostly NATO Partner) countries. Participation of key European and world-wide organisations in talent support and science education, such as the Commission of the EU, the European Council of High Ability, UNESCO, Ashoka International etc. made a special impact of the event.

The participants of the meeting adopted the following agenda to foster future world-wide collaboration between scientific research training initiatives:

1. The organizers will develop the current web-site **(http://www.chaperone.sote.hu/natowork.htm)** of the meeting to an interactive web-forum of scientific research training practices. Both the upgraded web-site and an email-network will be used for the dissemination of new practices as well as for the development of multilateral contacts.

2. A Network of Excellence for student, teacher and scientific research training organizer exchanges will be established. Several of these exchanges were already agreed on at the meeting. The Network will organize international joint research teams, and will also help the dissemination of best scientific research training practices world-wide.

3. Participants proposed a follow-up meeting two years from now, in the spring of 2004. As a result of the continued networking during the coming two years the follow-up meeting would be an excellent occasion for the evaluation of projects and to invite scientific research training organizers and novel interested participants from even more countries than those represented at the current meeting.

Author Index

Anciguer, Lucilene 108
Aspell, Jane 278
Ax, Laura 99
Borghi, Lidia 147
Borsodi, Zoltán 191
Brandon, David 77
Carvalho, Edison Durval Ramos 108
Conley, Jill 129
Connolly, Peggy 138
Csermely, Péter 1,191,305
De Ambrosis, Anna 147
Dotan, Muli 77
Erös, Barbara 99
Fleiss, Ida 60
Freeman, Joan 17
Herskovits, Maria 44
Jigău, Mihai 251
Joklik, Otto F. 233
Kaiser, Bonnie 178
Kakareka, Eleanora 222
Kevereski, Ljupco 218
Korcsmáros, Tamás 191
Korlevic, Korado 199
Kotlyarova, Margarita 222
Kucukkaya, Ayse Gulcin 185
Lay, Jasna Cvetković 159
Laznibatová, Jolana 227
Lederman, Leon 1
Leikin, Roza 77
Limont, Wiesława 53
Macarini, Samuel 108
Malpede, Diana 1,243
Mariychuk, Ruslan 211
Mascheretti, Paolo 147
Medrano-Asensio, Gregorio 1
Nayak, Lina 138
Nichols, Rodney W. 259
Pató, Bálint 191
Petrus, Vasil 211
Pitayataratorn, Janewit 237
Reyero, Marta 63
Righetti, Benito 1
Shlomit, Rachmel 283
Shmookler, Sandra R. 169
Sohlberg, Ragnhild 1
Stoycheva, Katya 31
Subotnik, Rena F. 295
Szabó, Gábor 1
Szczesniak, Eric 138
Tourón, Javier 63
Vondrakova, Eva 89
Wagner, Harald 117
Zaslavski, Orit 77
Zorman, Rachel 283