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Addressing Global Environmental Security Through Innovative Educational Curricula

Edited by
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Lia Stelljes
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Springer

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Addressing Global Environmental Security Through Innovative Educational Curricula

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Series C: Environmental Security

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PREFACE

At the NATO ARW workshop on Enhancing Environmental Security in Transition Countries (Sibiu, Romania, 2006), the assembled experts identified the inadequacy of the traditional Soviet/Eastern European approach to higher education as a major hurdle toward achieving environmental security in transition countries. While this system of education has excelled in promoting discipline-specific detailed investigations of basic science, especially natural history, and advanced engineering (nuclear physics), it has not approached education with an emphasis on applied science, interdisciplinary thinking and holistic problem solving. Thus, it is difficult, and sometimes impossible, for research teams to approach and solve issues of environmental security, such as resource conservation, water pollution, food production, and air quality in a manner that addresses the multifaceted nature of these issues. We will need a global community of educators adept at training young people to work cooperatively to solve local, regional and international environmental problems. NATO and its partner countries clearly recognize the importance of this area for research: environmental security is a priority research topic for NATO and for 11 of 15 partner countries.

The time is ripe for rethinking educational strategies, methods and goals. In 2005, the United Nations launched the Decade for Education on Sustainable Development. Universities in North America and Western Europe are responding to this call. Both University Leaders for a Sustainable Future and the American Association for Sustainability in Higher Education (AASHE) have grown exponentially in recent years: the AASHE annual conference saw a fourfold increase in the number of participants in two years. Likewise, the dialogue on curriculum innovations for promoting sustainability and environmental security is expanding. In transition countries and those of the former Soviet Union, universities are now stable enough in terms of finances and faculty to examine changes in curriculum and teaching approaches. Reforming higher education of transitional countries is a monstrous task, and there are several efforts currently underway, such as the Tempus Programme of the European Union. Another organization working in this area is the Alliance of Universities for Democracy, whose mission is "to enhance the role of education in promoting democratic institutions, economic development including technology transfer, decentralized decision making, human health, sustainable habitation of the earth, and common moral and social values", and it holds an annual conference for academic exchange between professors and administrators from Central and Eastern European Countries with those of Western Europe and North America.

Given the importance of education in environmental security and sustainable development, we convened a NATO Advanced Research Workshop (ARW) on "Rethinking Higher Education to Meet the New Challenges of Environmental Security" in Kharkiv, Ukraine in May 2008. This meeting brought together 36 international scientists and practitioners from fourteen NATO Member, Partner and Mediterranean Dialogue countries to identify the key weaknesses in higher education for addressing issues of environmental security and sustainability challenges.

The workshop goals were to: (1) inform university professors how to adapt their curriculum and teaching strategies, (2) produce university graduates that are more capable of prioritizing, evaluating and managing environmental issues through exposure to a holistic approach to solving environmental problems, (3) strengthen ties among practicing environmental scientists, managers, and government officials, and (4) increase collaboration among faculty in higher education and between colleagues in NATO member, Partner and Mediterranean Dialogue countries.

The teaching of environmental studies is well developed in North America and Western Europe where the principles of sustainable development are taken into account in teaching environmental problem solving. The approach is interdisciplinary with a focus on integrating the physical and natural sciences with the social sciences. Yet, these countries face additional challenges to address issues of unsustainable resource use, which in the area of energy, for example, poses an enormous risk to environmental security. In transition countries, this teaching approach has yet to develop and mature. Most environmental teaching focuses heavily on the sciences with little integration with other disciplines, specifically the social sciences. This workshop initiated the development of a broader based approach to the teaching of environmental studies by identifying the most significant health and environmental issues; addressing environmental security and sustainability issues within the local socio-economic constraints; identifying and prioritizing the most cost-effective educational strategies; promoting effective decision-making; and, making the best use of limited resources to achieve the greatest net environmental benefit.

We hope that educators will be inspired to develop and implement new approaches to teaching that provide students with the interdisciplinary knowledge base and applied skills from workplace internships that they will need to ensure environmental security in the decades ahead.

Publication of this book would not have been possible without the assistance of the staff of NATO's Science for Peace Progamme and Springer Science Publishing Division. We are especially grateful for the support provided by Dr. Deniz Beten of NATO's Public Diplomacy Division and the Susan Kassouf of the Christian Johnson Endeavor Foundation that allowed us to convene the workshop. We also thank Mrs. Wil Bruin and Ms. Annelies Kerbergen of Springer for their constant guidance and assistance in the editing, formatting and publication of this book. Lastly, we thank all of the wonderful workshop participants, who gave their time, energy and impressive thoughtfulness to the common cause of enhanced environmental security through education. We look forward to continuing the professional relationships and friendships borne out of our common interests and experiences.

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PART I. CURRENT EDUCATIONAL PRACTICES AND THE NEED FOR CHANGE

GLOBAL AND EUROPEAN TRENDS IN HIGHER EDUCATION: IMPLICATIONS FOR UNIVERSITY CURRICULA

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Abstract: This paper looks at the various effects of globalization on higher education, analyzing how the closer relationship between economy, the state and the university fit into the concepts and rhetoric of "knowledge society" and "mode 2 university". The focus is on recent developments in the European higher education, particularly on the changes triggered by the signing of the Bologna declaration. In a somewhat narrower sense, the paper also discusses the ways in which the Bologna process – its values, principles, and objectives – should prompt not only structural, but also content related, changes in university curricula.

Keywords: university; higher education; global trends; knowledge society; curriculum; Bologna process

1. The Changing Role of Universities

There has never been a single definition of what a university is and what its role should be. Historically, universities have become independent of the church and the state, and their primary role has been that of carrying out research and offering teaching (Humboldtian model of university). Teaching and research remained core functions of the university. Recently, however, a third mission has been added, that of serving the needs of national/regional/global economies and offering public service to national states.

Much of the twentieth-century rhetoric on universities talks about a segregation between the university, the market and the state. University's autonomy, however, is considered to be relative, as higher education remained strongly connected to the society, particularly through the knowledge that it produces, or rather is expected to produce. Authors like Ronald Barnett talk about a triangle of forces (Barnett 1993), whereby society, knowledge and higher education act upon each other as separate forces, while Gerard Delanty considers the university as a key institution of modernity where knowledge, culture and society interconnect (Delanty 2001). Other scholars argue that modern knowledge production is characterized by a new mode, "mode 2 of knowledge production" (Gibbons et al. 1994).

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In this new mode of knowledge production, research and enquiry are driven by the interests of the society and the economy, rather than by the ones of the academic world. Much emphasis is placed on who will be the user of the produced new knowledge and how knowledge will be used, and less on "why, where and how" knowledge has been produced. Research problems are often shaped by non-academic agencies that commission the research, provide funding for it, and use the results for a specific purpose rather than by purely academic curiosity. In earlier times, as Steve Fuller argues, the very term "knowledge management" would have been considered an oxymoron, as knowledge has been viewed worth pursuing for its own sake, regardless of its costs or benefits (Fuller 2005).

The transition to a "mode 2 society" (through the emergence of the knowledge economy and knowledge societies) is also leading to the development of a "mode 2 university", whose mission and functioning, as described by Harloe and Perry, are closer to the policies of national governments and the market and is more directly responsive to national and regional needs (Harloe and Perry 2004).

2. The Effect of Global Trends

With the process of globalization, these economic and social needs have become increasingly complex. Problems of societies and the environment are "multidisciplinary", only rarely approachable from the perspective of a single discipline or branch of science. Therefore, "mode 2 universities" are carrying out research in cooperation with other institutions in an interdisciplinary fashion, often using teams of experts coming from a variety of disciplines and sectors of the economy and society. In this context, besides producing new knowledge through research, universities become institutions where knowledge produced elsewhere in the society is transformed and validated; it is conceptualized, categorized, and introduced into the curriculum. The university, as Delanty puts it, is now "an institution that mediates, or interconnects, several discourses in society".

Such a large scale cooperation with various stakeholders also requires universities to look for new funding schemes. International organizations, institutions and funding agencies, such as the European Commission, World Bank, etc., are becoming important funders of knowledge production. Their role in shaping higher education policy worldwide is becoming more and more important, particularly when contrasted with the declining public funding of universities (Bassett 2007). The process is slowly but steadily leading to a stage when higher education becomes "an object of world trade" (Nunn 2002).

The development of the global knowledge economy can also be situated within a broader process, which Nowotny et al. (2001) describe as the "contextualization of science" in which "science and society have invaded each other's domain". The unity of teaching and research, as once assigned to the Humboldtian university, has taken a new shape – the knowledge society universities are engaged in the creative destruction of social capital. Research is the generator of social capital, as those involved in its production are the primary beneficiaries, while teaching reduces this "market advantage" by making research findings available to students

and to the larger public by dissemination and publications (Fuller 2003). The often mutually exclusive expectations towards universities' contribution to the shaping of knowledge societies and the global economy raise a series of concerns about the fundamental principles of functioning and the structure of the classical university. Should institutional walls built between academia and non-academia be maintained, or should they be demolished? Can disciplinary-based sciences be expected to realistically contribute to economic performance (Gibbons 2001)? Should degree programs that are unresponsive to market conditions be closed, and should university departments be converted into temporary interdisciplinary units that can be re-shaped according to global and local market demands (Fuller 2008)? As there is a demand from the side of the economy and society for new skills, should universities focus their curricula on developing employability by focusing on skills relevant in the labor-market rather than on knowledge and values? Should students be encouraged and taught to be market-oriented and "flock to courses which offer a passport to employment in the dynamic sectors of the economy" (Harloe and Perry 2004)?

3. European Developments

The ideas of university autonomy and academic freedom, as well as the relationship between politics, economy, and higher education, have been issues of serious discussions in recent years, particularly in Europe. The re-writing of universities' mission has often followed what Pavel Zgaga called the logic of a pendulum: a total dependence on political and economic activities gave way to an "autistic" position, one that lost sight of the public mission of the university (Zgaga 2003).

Indeed, the European higher education went through very significant changes during the last 15 years of the twentieth century. The "pendulum" first moved into the direction of recognizing universities' autonomy and the freedom of research and teaching. Rectors of European universities, gathered in Bologna on 18 September 1988, signed the Magna Charta Universitatum, whose first fundamental principle reads as follows: "*The University is an autonomous institution at the heart of societies differently organized because of geography and historical heritage; it produces, examines, appraises, and hands down culture by research and training. To meet the needs of the world around it, its research and teaching must be morally and intellectually independent of all political authority and economic power*".

Some years later, in June 1999, the pendulum seemed to move in the opposite direction: higher education stakeholders of a totally different kind – ministers and government representatives, have formulated and signed the Bologna declaration, the principles of which contradict the idea of independence of all political authority and economic power from the university. The purpose of the process that started with the signing of the Bologna declaration is to create a European Higher Education Area in order to increase employability of graduates, and the international competitiveness of European universities, by creating a common architecture of degrees and set of values. Signatories of the declaration hoped that

European universities would significantly contribute to the continent becoming, as the Council of Europe put it one year later in Lisbon, "the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" (Lisbon European Council 2000).

One of the major controversies around the Bologna declaration is that it was signed by representatives of states, but needed to be implemented primarily by rectors and deans. States and their governing bodies had to analyze and eventually reform their labor market and employment legislation in order to facilitate the employability of the new "Bologna graduates", but the main players in implementing the structural changes required by the Bologna process are still the universities themselves (Miclea 2003). Some of these universities, however, do not see the Bologna process as a goal in itself, but use it as a pretext for all sorts of reforms in university education and management, often unrelated to the content of the Bologna declaration.

The major structural change agreed upon by signatories of the declaration was the adoption of a system essentially based on two main cycles, undergraduate and graduate. Later on, at the September 2003 Berlin follow-up summit, ministers realized that in order to promote closer links between teaching and research "in a Europe of Knowledge", doctoral education should be included as the third cycle in the Bologna process.

The first cycle (bachelor's degree) should last for a minimum of three years, and should end with a degree relevant to the European labor market as an appropriate level of qualification. Many countries and universities, however, have interpreted the introduction of two-tier (later three cycle) degrees as a purely structural move that does not have to necessarily lead to qualitative curricular reforms. German students' report for the Berlin Summit (2003) called the implementation of the Bologna declaration a "failure". They argued that the transformation of traditional "diploma programs" into the two-tier degree structure was often realized by "cutting programs into two pieces". The same was the case in all former socialist countries of East-Central Europe and the former Soviet Union that were built on the traditional German model. The last one or two academic years of old diploma programs were simply re-named (with little transformation implemented) into specialized Master degree programs. In order to make the first degree a truly "exit degree" (i.e. being a degree that grants both employability and access to further studies and a degree that is chosen by a large number of students), a serious paradigm change is required in higher education. Universities and degree programs need to reformulate the learning outcomes for their various degree programs and adjust the content of their curricula accordingly. The proportion of mandatory and optional courses, as well as the combination of theoretical and practice oriented courses, need to be rethought in light of the changes required by the European labor market and higher education areas. The guiding question in a thorough reform should be: what chunk of knowledge from a given discipline and what kind of skills should be taught in the first three years of university education, so that graduates can find good jobs after getting the Bachelor's degree, but are also ready and motivated to enter graduate programs? The task of selecting the content and teaching methods

for accomplishing such a dual learning outcome is in itself difficult, no matter what subject one considers.

The issue is further complicated by the fact that the Bologna process requires universities to assure a free movement of their students, teachers, researchers and administrative staff between universities in other countries. This mobility is made possible and encouraged by the adoption of a European credit system that allows students to take courses from other universities. But why would any student, teacher or researcher want to study or teach in another country, at another university? One would hope that it is the "attractive and competitive" content of the curriculum and the quality of education that attracts students to studies abroad, as well as the available funding for such an endeavor.

Indeed, the Bologna declaration wishes, on one hand, to attract students from non-European countries (by offering them scholarship programs), but, on the other hand, it also wants to promote a European dimension in higher education, "particularly with regard to curricular development, inter-institutional cooperation". One might say that the Bologna declaration has an intra-European agenda consisting of the promotion of European values and offering degrees relevant to the European labor market, as well as an extra-European agenda of increasing the competitiveness of the European system of higher education in the global market. Students from other world regions should see the post-Bologna integrated university system of Europe as offering them degrees and qualifications relevant to their careers. A new set of challenges arise then: can one build university curricula in all disciplines in such a way as to simultaneously promote European values, train the future European labor force and address global issues? Would the degrees be relevant to both the European and global markets? In the interpretation of the Confederation of European Union Rectors' Conferences and the Association of European Universities, the Bologna declaration "reflects a search for a common European answer to common European problems". Are these European answers also addressing global problems?

As the Bologna process does not prescribe a uniform European curriculum, it gives no guidelines on what type of content, approach and methodology should be selected by universities in building their new degree programs. "Internationalizing the curriculum" seems to be a plausible solution, though the term has different meanings in different countries, universities and in specific disciplines. In some cases, it simply means introducing courses taught in English for an international student body. In other cases, it means a truly international faculty teaching interdisciplinary courses that address European and global issues by using a variety of sources and approaches. Yet in other cases, it is manifested in university networks collaborating across borders and setting up joint degree programs.

The mobility of students and faculty members within the European higher education area is expected to contribute to the development of a system of quality assurance that is based on comparison and benchmarking. Networks of European quality assurance agencies have been developed in a few years, and discipline-specific benchmark statements on expected learning outcomes have been formulated for all degrees. The true quality of education, however, can only be improved

through significant changes in the content of university curricula, and that seems to be a much longer process.

4. Conclusions

Almost a decade after the signing of the Bologna declaration the main questions on the future of European higher education are the following: will Europe, as a sort of supranational state be able to create a higher education system that will foster a multinational European cohesion, or is the emerging European higher education area doomed to be dissolved in global economic, political and cultural trends? Is there a need for a distinctly European higher education area, or was the whole idea of creating and maintaining a university system based on common European values and addressing specific European problems already outdated when conceived?

Within the context of the development of knowledge societies and global economies, can universities in Europe and worldwide maintain their academic integrity and transformative role in societies, or will they have to follow the rules of the market and become entrepreneurial institutions that can only survive in the long run if they address globally relevant issues?

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SCIENCE ON THE MARSH: TOWARDS THE GROUND OF EDUCATION (FOR SUSTAINABLE DEVELOPMENT)

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Abstract: This paper discusses sustainability research and education at the university level. The family of metaphors around science "at sea" is introduced and further developed in an attempt to reflect on education experience in the domain of sustainable development. The accounts of "normal" and "post-normal science" are introduced to elaborate on "science at sea", and then "science on the marsh". Drawing the implications of this discussion on education, a two-tier structure emerges: (1) the initiation into particular, disciplinary scientific communities, (2) learning to be a participant in formulating and dealing with social and environmental problems in a context of multiple authorities and multiple strategies for problem solving. Education, understood in this way, plays an intrinsic and instrumental role in sustainability science – it makes research sensitive to life-world problems and concerns, and it prepares researchers to effectively communicate their research outside the scientific community.

Keywords: education for sustainable development; post-normal science; sustainability science; environmental education; metaphors; water; environmental security

1. Introduction

Embarking on the sea, leaving the land, the "natural" ground of human life for the "limitless" ocean and its dangers is for the ancients a transgression; it is to throw away the sufficient fruits of the land for the risky und uncertain promises of the

[1] I would like to thank the organizers and participants of the ARW Workshop for a stimulating week, and administration, students, faculty and guests (especially Michal Kravcik) at the European College of Liberal Arts (and before at McGill University and Freie Universität Berlin) for exploring with me some of the issues discussed here. Specific thanks are to Jerome Ravetz for written comments, and to Lia Stelljes and Susan Allen-Gil for their editorial work.

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Sea (Blumenberg 1979, 10 f). But even modern thinkers retain an acute sense of the risk. Shipwreck is an end of civilization; is it any crime, asks Hume, after shipwreck, to seize whatever means or instrument of safety one can lay hold of, without regard to former limitations of property (Hume 1751, 18)?

Yet, a central political concept, "governance", derives from the Greek *kybernan*: to steer or pilot a ship. Plato famously employs it to question whether the demos, rather than experts, should and could steer the "ship of state". And a guiding metaphor of twentieth century science following Otto Neurath is that of sailors on the open sea who must reconstruct their ship, but are never able to start afresh with the best materials on a dock (Neurath 1932/3, 206).

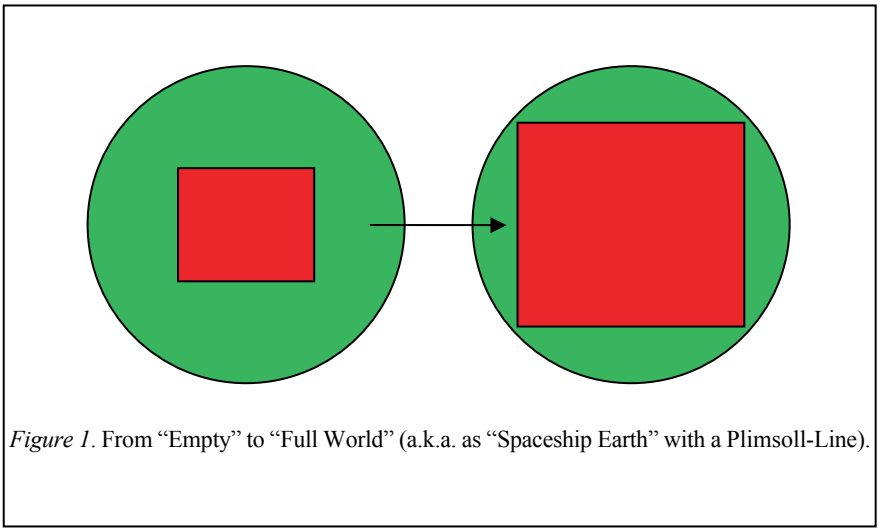

Figure 1. From "Empty" to "Full World" (a.k.a. as "Spaceship Earth" with a Plimsoll-Line).

In sustainability science,[2] the scientific and political use of the ship metaphor has become planetary ("Spaceship Earth") and received new specifications: "to avoid overloading and sinking even a well-balanced boat, we have a Plimsoll line defining the absolute scale limit" (of the economy with respect to the environment) (Daly 1992, 192[3]). The metaphor of the "spaceship earth" and the further specification of this metaphor in terms of the "Plimsoll line" capture the need to think about the limits to economic growth within a finite biophysical world. In Figure 1, the square refers to the global economy, and the circle to the biophysical planet as an envelope of the economy. With economic growth this square "grows" from an "empty" world with many unused economic resources and sinks to a "full" world that faces limits to resource exploitation and to the regenerative capacity of ecosystems.[4]

[2] I use the term (sustainability) "science" to refer to both research and education.

[3] The "Spaceship Earth" metaphor is invoked by ecological economists following Boulding 1966.

[4] Following the influential work of Boulding and Daly cited above, variations of this graph can be found in many sustainability texts.

This family of metaphors vividly captures limits, but it has little to say about the question of governance, and of the relation of science and policy. Who is the captain on "Spaceship Earth"? Does the Earth need a captain? And what are the educational implications of these questions? In this paper I will employ and further develop this family of metaphors (and the questions they raise) in an attempt to reflect on education for sustainable development. My goal is to say something about the structure of this education based on educational experiences already made.[5]

I will start in Section 2 with the metaphor of "science at Sea". The work of the historian of science Thomas Kuhn on what he calls "normal science" offers one way to work out what I take to be important features of "science at Sea". In particular, "science at Sea" stands for independent scientific communities with no intrinsic relation or responsibility towards society and its concerns. Accordingly, the primary task of education is the preparation of the student for the life as a science-sailor (or perhaps as a "spectator" of science at Sea, not least because the triumph of science has been accompanied by fears of civilizational shipwreck).

Section 3 turns to scientists working on environmental security in the domain of water. As we will see, Kuhn's account of "normal science" does not describe this type of research very well. Moreover, the work done by the scientists discussed in this section suggests a need to resituate "science at Sea". The hydrologist Michal Kravcik and his collaborators describe modern water management as an impressive and sustained effort to drain wetlands, to straighten rivers and to sluice the water into the ocean as quickly as possible – with far reaching consequences for vegetation, agriculture, the climate and human communities. They argue for a new water management that would "return the lost water back to the continents" (Kravcik et al. 2007, 68, also see Section 3 below). Adopting the perspective of the "lost water" claim, we can describe sustainability science and education as (re)-claiming ground: the (forgotten) land as the standpoint for sustainability science and education. Section 4 turns to the work of sustainability scientists Silvio Funtowicz and Jerome Ravetz, who I take to offer an important account of the structure of such research (which they call "post-normal science"). Section 5 draws the implication of this research on education, and the conclusion summarizes the resulting structure of education as a two-tier structure built on both "normal science" (and its peer-based authority structure), as well as "post-normal science" (and its extensions of the authority structure to include non-scientists). This structure calls for the integration in education of "science at Sea" on the one hand, and of the concerns and needs of citizens who live "on the land" on the other hand. The ecologically highly sensitive place where sea and land, water and Earth meet is the wetland – accordingly I speak of the emerging format as science and education "on the marsh".

[5] For the education experience, see the Appendix.

2. Science "at Sea"

My starting point for science and education "at sea" is Thomas Kuhn's contribution to the history and philosophy of science. It is not only a seminal contribution to the history and philosophy of science, but it also has two features pertinent for the current discussion: it focuses on the social structure of science, and as we will see it continues to influence scientists working in the domain of sustainable development. In this section, I will introduce Kuhn's account via its central concept, the "paradigm", and then consider its implication for education.

His historical studies lead Kuhn to proclaim a first sense of "paradigm".[6] In his view, scientific communities form around scientific achievements that the community acknowledges as the best approaches for dealing with a widely recognized problem or set of problems (Kuhn 1962, Chapter 2). These "paradigmatic" approaches might be found in classic texts such as Aristotle's *Physics* or Newton's *Principia*, or they might be presented in textbooks (e.g. Franklin's explanation of the Leyden Jar). These scientific achievements do not only unite the scientific community, they are, according to Kuhn, also sufficiently open-ended to leave many problems for the community to resolve. They promise a solution, that something can be done, but they have not delivered (yet) solutions to all known problems.

The paradigm thereby offers the space for the labours of what Kuhn calls "normal science". Members of the scientific community will seek to generalize the findings implied by the exemplary achievements, work on the precision and completeness of measurements and data, and refine the theoretical articulation. In this work, normal science is guided by commitments to preferred types of instrumentations and metaphysical commitments about ontology and method. For example, eighteenth century scientists, following Newton's *Opticks*, take a universe composed of microscopic corpuscles for granted and believe that mathematical laws can ultimately specify corpuscular motion and interaction. On this account of "normal science", the *paradigm* is a very general term describing the theory and practice guiding a scientific community: deriving predictions, extending the scope of the paradigm, refining the articulation of the theory, and gathering facts – doing the "mop-up work" (Kuhn 1962, 24).

The works of "normal science" have their social organization. Kuhn describes the members of scientific communities as guided by a paradigm: they do not disagree on the fundamentals, they share a "vision" and have the faith that it can solve all problems, and they are generally intolerant of the theories of others (Kuhn 1962, Chapter 3, and also 165 ff). The work of the community is organized by scientific societies that organize conferences and workshops and publish special journals all exclusively devoted to the problems and ways of dealing with them recognized by the community. The members of this scientific community, and only they, are the relevant peers. Even if students are initially attracted to science

[6] The many meanings of the term "paradigm" in Kuhn have been noted. See, in particular, Masterman (1970). However, the two senses outlined here are particularly important for Kuhn's account and for our purposes.

by reasons such as the desire to be useful to society, the motivation of the scientists within the scientific community is to be recognized by their community peers as "expert-puzzle solvers" (Kuhn 1962, Chapter 4).

From this account of science, a distinctive perspective on education emerges. Scientific education is the initiation into a community and its paradigm. The established members of the community are the sole authorities to define the primary goals and methods of this education, which is an introduction into the fundamentals of the paradigm and the techniques required for expert puzzle-solving. The paradigm itself is not questioned, but vigorously defended against rival theories. Textbooks introduce the paradigm, and may, to this end, tell a history of science. This is not a history concerned with historical accuracy, but a history used to initiate the students (hence history is possibly presented as a process towards this paradigm, the paradigm as the culmination of scientific history, etc.). One task of the educator is to turn the student away from social (or other larger) concerns that may be useful (to society), but cannot be recognized and or solved within the paradigm. "We have already seen, however, that one of the things a scientific community acquires with a paradigm is a criterion for choosing problems that, while the paradigm is taken for granted, can be assumed to have solutions. To a great extent these are the only problems that the community will admit as scientific or encourage its members to undertake. Other problems, including many that had previously been standard, are rejected as metaphysical, as the concern of another discipline, or sometimes as just too problematic to be worth the time. A paradigm can, for that matter, even insulate the community from those socially important problems that are not reducible to the puzzle form, because they cannot be stated in terms of the conceptual and instrumental tools the paradigm supplies. Such problems can be a distraction, a lesson brilliantly illustrated by several facets of seventeenth century Baconianism and by some contemporary social science" (Kuhn 1962, 37).

Let me end with a final remark on "science at Sea" following this quote. The independence of "normal science" from social, and therefore also political, concerns offers a central justification of the idea of science as "speaking truth to power". But while autonomous scientific communities are (at least in the ideal) independent from political interests, the quote from Kuhn also indicates another implication of this autonomy. This science may simply not have much to say about social problems, which may be "too problematic" for puzzle-solvers. To put it polemically with a well-known quip: a science that is brilliant, and perfectly irrelevant – how then can it be speaking truth to power?

3. Environmental Security: Science and Water

Yet, no matter problems being "too problematic", scientists have continued to engage with socially important problems. Environmental security, the topic of this workshop, is one such domain. Let me therefore briefly turn to some examples from the discussion of water management in relation to security.

Environmental security requires the study of causal relations between environmental problems and social struggles. For example, water scarcity has been discussed as a cause of "water wars" between countries (Fröhlich 2006, 32–37). In this context, environmental security is seen as a question of national sovereignty and (perceived) threats to it. For example, the US-Department of Homeland Security has a budget of more than US$500 million for securing US-water infrastructure, the US-Environmental Protection Agency has founded a National Homeland Security Research Centre mandated to work on the means of fighting attacks on the US water system, and the Water Security Division trains water utility personnel on security issues (Barlow 2008, 148 ff).

Apart from national security concerns, there is also a concern with environmental security understood as "human security". The 1994 Human Development Report defines this concept as "safety from the constant threats of hunger, disease, crime and repression". It also means protection from sudden and hurtful disruptions in the pattern of our daily lives – whether in our homes, in our jobs, in our communities or in our environment (UNDP 1994, 3). With this understanding of security too, the work of scientists remains important – for example on the relation between water management and food security. As 70% of the global fresh water supply is used in agriculture, water scarcity can quickly lead to challenges in food provision (particularly in countries where agriculture requires much more than the global 70%, see Lotze-Campen 2006).

An example dynamically linking the national and the human security dimensions is the relation between water management and disruptions in the environment due to climate change. Hydrologist Michal Kravcik and his collaborators have pointed to the relation between the draining of land, decreasing evaporation, and a rise in extreme weather events. By following the water policy of modern states, Kravcik argues, wetlands were drained, river flows were straightened, and meanders and dead-end tributaries were removed so that water could be sluiced away as quickly as possible (Kravcik et al. 2007, 64[7]). But as a result of the drainage, Kravcik argues, there is less evaporation of water from the land and more sensible heat production, which in turn impacts the weather. Finding community-based ways to return the "lost water to the continents" is in this view a key contribution in the response to climate change.

Water security as a matter of national security has often been questioned. For example, in spite of warnings of "water wars", river basin management is one of the few areas of co-operation in conflict areas (Fröhlich 2006). However, at the very least, the links between water management and various human security issues continue to remain much researched, and I therefore would like to use it as my example for the further discussion of research and education.

Research on food security and climate change can be easily distinguished from the "normal science" described above. The natural and social scientists involved do not follow a strict focus on the study of "nature"; they accept social issues (e.g. human security issues) as a consideration informing their research. This is most

[7] Kravcik's claim about modern states is corroborated by recent historical work. See Blackbourn (2006).

evident in the fact that this research includes the discussion of practical solutions to these issues. For example, in response to the question of water scarcity and food security, scientists discuss and propose efficiency improvements, institutional reforms (water pricing) and new concepts such as the consideration of "virtual water" in trade (Lotze-Campen 2006, 11 f). Kravcik et al., in their discussion of water management and climate change, propose rain harvesting and water conservation measures.

The contrast to "normal science" can be seen at a basic level when considering the use Kravcik et al. make of the term "paradigm". To be sure, a "paradigm" for them just as for Kuhn is not just theory, but is also practice and tradition (Kravcik et al. 2007, 65). However, the practice and tradition is not that of a scientific community considered in isolation, but rather that of science and technology considered in the context of political organization. According to Kravcik, in the "old water paradigm", the focus is on the modernist state and its centrally planned, often technologically very impressive, water management system (great dams, sewage systems etc.); in the "new water paradigm", the focus is on multi-levels of governance with priority given to the lower levels according to the principle of subsidiarity (Kravcik et al. 2007, Chapter 7). In short, on this use of "paradigm", both the new and the old "paradigm" cannot be understood without considering political organization and normative questions related to it.

4. Moving to the Land

The examples from environmental security in the last section and the research interests of scientists in this domain suggest that Kuhn's account of "normal science" is at least incomplete. There is a large domain of science that does not follow the "paradigm" as described by Kuhn.

In a series of articles, Silvio Funtowicz and Jerome Ravetz have situated sustainability science in a context where facts are uncertain, values in dispute, stakes high and decisions urgent.[8] Global social and environmental issues, they write, require science to deal with issues involving multiple systems, their interrelation, and contested normative issues. The triumph of science and technology itself requires decisions involving irreversible, unpredictable and socially and ecologically very far-reaching consequences. Yet, precisely because the facts are uncertain and values are in dispute, we see a social organization very different from "normal science". The scientific community is neither able (nor necessarily willing) to exclude outsiders from the discussion of problems. We see extended peer-reviews involving scientists and laypersons in the domain of science for policy. Funtowicz and Ravetz speak of "post-normal science".

[8] Funtowicz and Ravetz (1991, 1993); Funtowicz et al. (2000).

However, this is not just a de facto observation about the insufficient power (or will) of scientists to keep science "normal". There are reasons for extended peer reviews.[9] For sustainability issues, there is generally not "one" solution to a given issue, but various plausible perspectives and approaches. Therefore, including these various perspectives can serve as a means to reduce ignorance. The natural scientist interested in the consequences of climate change needs to work with social scientists in order to model possible (and plausible) social responses to various changes in the environment. But, it is not only a matter of interdisciplinary debate. Non-scientists are also to be included, as they may have tacit knowledge of great value for understanding local contexts and for developing local solutions. Also, to the extent that disciplinary science requires a high amount of specialization, others can effectively help scientists "discover" the limitations of their approach. Moreover, a close-knit community science may have considerable difficulty engaging in self-criticism. To effectively engage in such criticism, outside perspectives are helpful. Merely interdisciplinary criticism may not be sufficient to the extent that the interdisciplinary discussion takes places within a shared tradition of Western Science that excludes other perspectives (Betz 2006, 244).

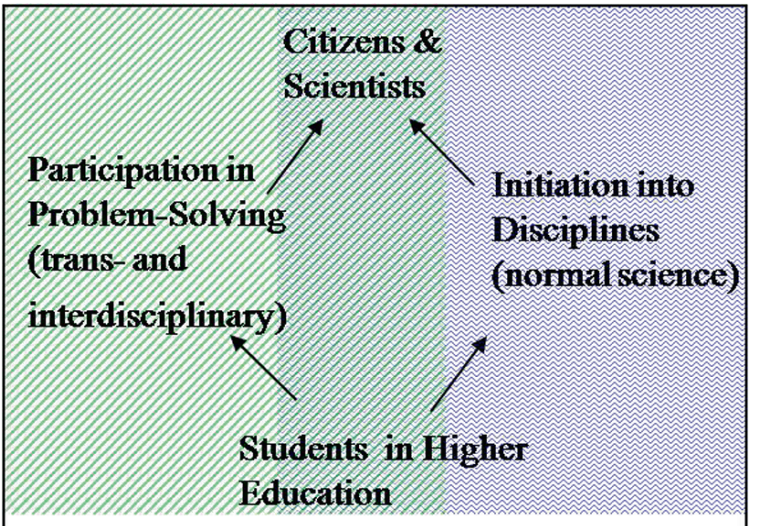

Figure 2. Two-tier education.

[9] For a very lucid account of the epistemic reasons that can be given for extended peer communities, see Betz (2006). I present, in much abbreviated form, some of the epistemic arguments worked out by Betz.

What are the implications for higher education?[10] Even the "post-normal science" analysis includes a (qualified) form of normal science. No doubt, facts and theories are still required and necessary, and for this reason the initiation into and reproduction of scientific communities and their "normal science" remain important even from a "post-normal science" point of view. The students have to embark "at sea". Still, the "normal science" is situated in the context of policy. So what opens puzzle-solvers to the concerns and arguments of outsiders? One answer might well be education, as long as this education is one in which students are not initiated by authorities into exclusive scientific communities, but are also participants in a learning process that involves scientists and lay-persons (students and guests) in a problem-solving activity with multiple authorities. Without a doubt, the lay-mind of the student has always helped to "cure" and "refresh" the narrow-mindedness of the specialist teacher. But as long as that teacher is the sole authority, this effect can only go so far. Therefore, an education context with explicitly multiple authorities is better. People from different disciplines, including people from outside academia (for example people directly affected by the problem discussed), are to be included in the education effort, improving the classroom preparation of science for policy. Because this is an education context, and hence likely less contested than situations in formal politics, it seems more likely that people will learn to deal with multiple authorities and to engage in dialogue.

The last paragraph suggests a twofold education (also see Figure 2): (1) the initiation of students into particular scientific communities, (2) the participation of students in a problem-solving activity with multiple authorities. To be sure, to the extent that science for policy (especially regarding global social and environmental issues) has effectively reduced the authority of scientists, such education may have already emerged. It is closely linked to the (Hegelian) tradition that understands education as a process of *Bildung* that not only inserts human beings into one system or discipline, but is simultaneously a process of learning about the relation between this system and its political, social, ecological and economic environment.

5. Toward the Ground of Education

To my knowledge, there is little direct discussion of the educational dimension in the post-normal science literature. This lack of discussion is hardly specific to this literature. My own research is funded by the German Federal Ministry of Education and Research and its programme for social-ecological research (Wächter and Balzer 2008). The programme seeks to support the implementation of the national sustainability strategy (ibid. 7, 13); research "projects should refer to life-world problems, and thus to research issues not generated within the realm of science" (ibid. 15). As a social-ecological programme it is interdisciplinary – the research is to focus on both *ecology*, defined as the "material-energetic aspects of human

[10] As noted, this question has hardly been asked in the literature as far as I can tell. Accordingly, the following discussion does not represent accepted "post-normal science" views, but rather states what I take to be (some) implications of sustainability science for education.

beings and the organic and inorganic world surrounding them", and the "processes and patterns of social action and interpretation exhibited by people in their dealings with nature and society" (ibid. 15). The research projects are also to be trans-disciplinary; "it is also necessary to integrate non-scientific knowledge into the research process" (ibid. 15). In short, this research programme is well aware of the challenges and requirements of the science for policy discussed above. Yet, just as in the literature on post-normal science, there is little direct discussion of education.

Still, I think a number of reasons can be given why education should be explicitly discussed as a part of sustainability science. First, university education can be (and often is) one way in which the "life-world" has access to research. Via university education, "the life-world", in the form of not yet specialized students, gets a say on a permanent basis – provided that the students are heard. The discussion in the last section indicated a two-tier structure such education for sustainable development could take.[11]

Second, science for policy as "trans-disciplinary research" must, by definition, communicate with persons outside the respective scientific community. Education is a useful testing-ground for such communication (and the "quality" of the education in this respect is an indicator of the quality of the research). Students have the time and the curiosity to engage in dialogue, but the political interests that can be an obstacle to discussion in extended peer review processes are likely to be much diminished in the education context.

Third, it has been argued that concern with the environment is seen as unfair where people have urgent unmet social and economic needs (Allen-Gil and Borysova 2007, 418). But as a concern regarding the focus and legitimacy of sustainability science, it may depend on life-world problems not being "heard" in this research and the related education. There is an environmentalism of the poor, and the unfairness concern therefore likely due to a closed structure of education that in turn diminishes the legitimacy of sustainability science.

If these are (some) reasons why education ought to be a part of sustainability science, the inclusion along the lines indicated here no doubt also faces obstacles. Let me end this section with two challenges. The introduction of multiple authorities faces the danger that instead of an interdisciplinary or even transdisciplinary discussion, experts each speak *from* their perspectives *to* students. The education is then nothing but a sum of various normal science perspectives. If this outcome is to be avoided, students will likely have to play a central role as synthesizers and reviewers of the various perspectives. As the by definition non- (or not-yet) specialised, they might even be in a better position to achieve such synthetic reviews than disciplinary experts.

However, will they take such an active stance? The point made above that in the educational contexts political interests are usually much diminished (or at any rate more playful) is partly due to the fact that the students will often not be stakeholders comparable to other extended peer-review processes. For example

[11] In this paper I only discuss what might be a plausible structure of such education, and not the various ways in which this can be worked out – I suspect this task to be highly context-specific. For one example, see the Appendix.

locally affected farmers will have a direct interest in a review process concerning the evaluation of a local power plant, the consequences of GM-crop etc. In contrasts, students will be in general less immediately affected by such questions. For this reason it is important not to make transdisciplinary education a mere "extra activity" in contrast to the "serious" ("normal") science and its exams, but to include and give credit to this education. The currency of "normal" and "post-normal" education should be the same, or at least have a good exchange rate.

6. Conclusion: Science and Education on the Marsh

This paper is an attempt to reflect on educational practice in the domain of sustainability science. In this paper I have employed and resituated metaphors as a tool for reflection. In the Appendix an example for the education practice inspiring is added; on the one hand the example might help to make the preceding discussion more understandable, on the other hand the example indicates the origin of these reflections in North-American and European philosophy and liberal arts education – and therefore the likely limitations of my discussion.

Science has always been accompanied by metaphors that help formulate a pre-analytic vision that guides work in the production of knowledge as well as in the reproduction of the scientific community, i.e. in education. As sustainability science has its own context, we may well ask what these images and metaphors are, and what they might be. In this essay I have experimented with the familiar image of science "at sea" and its relation to "the land".

The educational proposal, arrived at in this way, will make it clear that it makes little sense to think of simple opposites of "sea" and "land". Following the work of Kravcik and his collaborators, there is no need to overdraw the contrast between "the land" and "the sea", "the earth" and "the water". Integrated water management seeks to restore the water on the land, in plants and ponds, in rivers and wetlands. It is a science and education "on the marsh" that calls for cisterns and terraces, but also for boats and docks. The marsh is not a static and secure ground, but the place of numerous (water and other) cycles that stand in complex relation to the human communities inhabiting the land. These inhabitants are not simply returned sailors-scientists, but an extended community of scientists and citizens. Normative questions are part and parcel of this ground, on which scientific organization cannot be thought of as a closed community, as independent of normative questions arising from the difficult task of living together.

I have discussed "sea" and "land" in relation to normal and post-normal science, and suggested a two-tier education: (1) the initiation into particular, disciplinary scientific communities, (2) learning to be a participant in formulating and dealing with social and environmental problems in a context of multiple authorities and multiple strategies for problem solving. Education, understood in this way, plays an intrinsic and instrumental role in sustainability research – it makes research sensitive to life-world problems and concerns, and it prepares researchers (and their audience) to effectively communicate their research outside the scientific community.

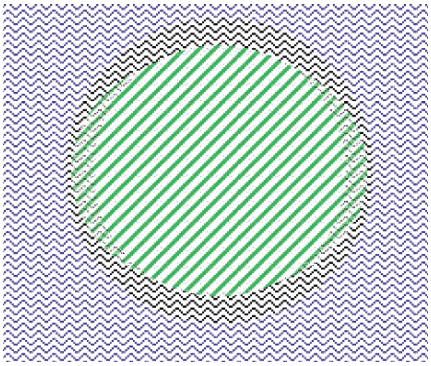

Figure 3. Science and education on the marsh.

The education structure that has emerged suggests a reversal and redescription of Figure 1. The "land" (the circle representing the Earth we live on) as surrounded by the "Sea" of Science. Science and education "on the marsh" is a call to pay attention to the meeting point of "sea" and "land", to the "wetland" where the insights of science (can) meet with the concerns and needs of citizens, to a fuzzy area rather than a straight "boundary", a call to search for "ports" so that the "ship" of science can return (if only also not to a "secure" ground), and a call for paths from the land into the marsh (see Figure 3).

Science and education "on the marsh" connotes treacherous paths and foul smells. After the draining of the land, the rectification of rivers, and the draining of wetlands, it may also connote a romantic motive of return to pristine nature. Let me therefore end this discussion with some qualifications.

Without a doubt, there are limitations and dangers to the use of metaphors. However, paying attention to post-normal science (and its implications for education) shows the image used here (Figure 3) to be supported by arguments for the present educational proposal. Moreover, scientific research, as other human activities, is guided by metaphors. In the introduction I have mentioned the use of "ship" and "Plimsoll line" metaphors in sustainability science. To the extent that such images have on board assumptions of normal science that do not reflect the context of sustainability science or that bracket important aspect of it, it is a useful exercise to reflect on the images guiding sustainability science (Höhler 2005).

Kuhn's account of "normal science" has been subject to much criticism (though of course his account has also provided a language that not only philosophers and historians of science, but also scientists, employ). In this paper I have used the Kuhnian language as a communication tool for addressing an interdisciplinary audience. "Normal" and "post-normal science" are much criticised concepts and may strike historians and scientists as misdescriptions of science. However, for the present discussion it is, I think, sufficient if sceptics of the language of "normal" and "post-normal" science accept the following basic difference as a salient one: between a scientific community that takes itself to be the sole source of authority

on the one hand, and extended peer-review on the other hand, which effectively licenses non-scientists to participate in problem formulation as well as in the assessment of the quality of the research being done.

The present discussion is limited to the discussion of education for sustainable development at the university level. But this is not the only level to which this discussion can be applied, and it is unlikely as important a level as that of early childhood education when orientations are acquired and specified (Ott and Voget 2007, 11).

Finally, the present attempt to work out a structure for education for sustainable development at the university level is open to many further questions – in particular, the question regarding its relation to key debates in sustainability science that this paper has not touched on such as the discussion of "strong" and "weak" sustainability and its implication for education for sustainable development.[12]

Appendix: State of the World Week as a Teaching Format for Education for Sustainable Development

This Appendix introduces an education format, the State of the World Week (SWW) – not because this format is the only one, and even less so because I think it is the most important one (I don't), but in order to give an example for the education practice that has triggered my attempt to reflect on education for sustainable development.[13]

The State of the World Week (SWW) at the European College of Liberal Arts in Berlin is a week-long, annual education format for the exploration of global issues. Most of the students attending are from the college, but the SWW is also open to alumni and external students. The week is co-developed by students and faculty, and also draws on the input of invited guests. In 2007 and 2008, a tight relation to education for sustainable development emerged, and has been externally recognized via the German UNESCO commission, which has included the SWW 2007 (on social entrepreneurship) and 2008 (on water) in its Decade for Education for Sustainable Development.

Let me give an outline of the SWW on water, in the week of May 5–9, 2008. Each morning, invited speakers lectured on the SWW-theme followed by Q&A. This traditional educational format was expanded by seminars offered by faculty in the afternoons. Lectures and seminars together offered an interdisciplinary platform for the discussion of water with specialist views from geography (cultural) history, hydrology, literature, philosophy, and political science.

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[12] For a discussion of education for sustainable development from a perspective of "strong" sustainability, see Ott and Voget (2007).

[13] I have co-ordinated the SWW in 2007 and 2008 (http://swwe.ecla.de/). The further personal experience I draw on is the design and teaching of courses on education for sustainable development at McGill University and at the Freie Universität Berlin.

These lectures and seminars were complemented by two student-led projects: a discussion panel on the privatisation of water, and the preparation of a water fund in collaboration with a German non-governmental, not-for-profit organisation, the *Wasserstiftung*. I shall focus on the second project, the Water Fund. Each afternoon, students, faculty and the invited speakers met for a Water Fund Table. During the preparation of the SWW in winter 2008, the student proposal for developing a project in support of a community in an arid area was responded to by the *Wasserstiftung* with the proposal to explore the idea for a new fund for the human right to water. The idea of such a fund had been entertained by the foundation for a while, but there had been a lack of time and resources to develop the idea; the SWW seemed to offer an opportunity to discuss the why and how of such a fund. The proposal was accepted by the students, and then discussed during the SWW as described above. At the end of the SWW, three models for the fund had been developed, and were voted on by the college community by the end of the week in order to make possible a report to the *Wasserstifung* that included a ranking of the proposals.

As this project arose from a NGO-proposal (in response to the student demand), the Water Fund can be called a trans-disciplinary project. A life-world problem has been taken up, discussed with specialists from the social and natural sciences, and the results of this discussion have been communicated back to the Stiftung. I attended this workshop just briefly after the SWW 2008; the process of communicating results back has not yet been completed. Achieving secure, safe and affordable access to water for people worldwide is no doubt an objective fraught with risk and uncertainty. Natural stresses such as those due to climate change, but also social conditions such as the structure of government and especially the increasing corporate interest in water as an economic good, mean that access to water in the above terms is contested and unpredictable. Hence the two-tier structure discussed above suggested itself as an education format.

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ENVIRONMENTAL SECURITY AND THE ROLE OF UNESCO CHAIRS IN HIGHER EDUCATION IN BELARUS

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Abstract: The UNESCO Chairs are responsible for the balanced combination of educational and research practices for the development of the national education system. Serving as a catalyst in the international experience of spreading processes, the UNESCO Chairs provide input for the adaptation of sustainability into the national higher education systems.

The main target of the UNESCO chairs in the Republic of Belarus at present is to assist with upgrading the contents and structure of the higher education system in the context of integration into the global space of higher education, including the necessity of introducing 'newest achievements' in the field of information and communication technologies, creating conditions for developing Belarusian tradition of education, based at national and world achievements of pedagogic and social science.

The development of intellectual collaboration and using the UNESCO Chairs resources will help to work out the programmes in the field of formal and informal education. Key priorities of the UNESCO Chairs in the Republic of Belarus are:

- The acquisition of concrete results, answering national interests and taking into account globalization processes
- The study of modern tendencies in the development of higher education
- Coordination of activities of educational institutions of the Republic in the choice of concrete ways of reproduction and renewal of educational traditions
- Assistance in working out methodical recommendations for the use of innovative, information and communication technologies in the instruction process
- Develop an efficient system of information exchange among the UNESCO Chairs and the UNESCO Secretariat
- Inviting sponsors' support, including international organizations, with the use of the UNESCO logo according to the existing rules
- Maintaining cooperation with the organizations that enter the UNO system
- Getting support from the Republican governing bodies by defining the trends of research

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The main prerequisites of the UNESCO Chairs' activities are integrating the national education system into the European Space for Higher Education.

Keywords: European integration; international co-operation; education; environment; sustainable development

1. Introduction

Environmental security is a priority for the state policy of the Republic of Belarus. Basic laws of the Republic of Belarus and international treaties guarantees the right to a favourable environment, ecologically-safe living conditions, information on environmental conditions, public participation in decision-making and environmental justice for each citizen.

The main goal of the environmental policy of the Republic of Belarus focuses on ensuring environmentally safe conditions for all people, which includes rational use and protection of natural resources, and elaboration of legal economic principles for environmental protection in the interests of current and future generations. Environmental policy of the government provides for structural reorganization of the production sphere, and improvement of production technologies, including resource-saving, application of low-waste and waste-free technologies, reduction of pollutants discharged into the air, and waste utilization and processing.

Implementation of the state environmental policy focuses on:

- Improvement of nature protection legislation
- Introduction of effective economic methods of management of and control over use of natural resources and environmental protection
- Setting up an integral system for financing environmental protection measures
- Improvement of the system of governing bodies and environmental control
- Implementation of a personnel training and retraining programme and increasing the environmental culture of the population
- Development of international cooperation and more active use of foreign experience in solving environmental problems

2. Problems with Environmental Security in Belarus

Problems of environment protection and efficient use of natural resources are considered important issues of sustainable development of every state, including the Republic of Belarus. The policy of the Republic of Belarus foresees consistent reconstruction of production process, improvement of existing technologies, applying resource-saving techniques, wastes recycling, decreasing of wastes and fallouts polluting nature, and the elimination of influence of human activities on the natural environment.

Presently Belarus faces an unforeseeable ecological situation caused by anthropogenic influences that affect forests, rivers, and lakes. One of the most important ecological problems for the Republic of Belarus remains to be radioactive pollution of more than 22% of the territory of the country after the Chernobyl atomic station explosion.

Another very important ecological issue for the Republic of Belarus is the unforeseeable ecological situation in cities with developed industry, particularly Novopolotsk and Polotsk which are situated in the industrial northern part of the country. These two cities are located less than eight kilometres apart from each other and include a variety of industrial enterprises such as oil-refineries, chemical factories, a large heat and power plant and one of the largest enterprises in Europe – a glass fiber production plant in Polotsk. According to a recent study (2006–2007) Novopolotsk has the highest amount of atmospheric pollution in the Republic of Belarus (50,800 t per year).

Quite another important environmental issue is the poor quality of water resources in spite of good environmental protection by the Republic of Belarus. The use of water is limited by its quality. The reason for poor water quality lies in the natural geochemical characteristics of the territory (large amount of iron and manganese) as well as anthropogenic pollution. The main part of the waste water coming into to the Western Dvina River is from the both industrial cities of Novopolotsk and Polotsk. Indeed, a very important source of surface water pollution is transborder transportation of pollutants. Very large amounts of water pollutants are imported from Russian streams into the Western Dvina River. The quality of water in the Western Dvina exceeds the maximum allowable concentration of colour, turbulence, manganese and iron (Kolobayev 2001). Other sources of anthropogenic pollution include leakage of compounds used in agriculture and leakage from old water-supply.

Due to social and economic barriers a huge problem must be tackled in the near future in Belarus which is the effective and legal use of the land. For example, land use in the territory of Vitebsk (the northern part of Belarus) is complicated due to the unique physical characteristics of the land. The territories near cities and close to roads are polluted with heavy metals, sulfur, fluorine and other compounds which adds to the poor situation in the country (Grinevich et al. 2006).

Other serious environmental problems exist within the Novopolotsk-Polotsk industrial area such as air and water pollution, and use of land and biological resources. Novopolotsk has the highest levels of contaminants in the country and represents a serious situation which has to be targeted in long-term work.

The ecological development of Belarussian society has started to play a crucial role in the social life of the country and even in the growing economic and judicial relations of the country. The increase in the importance of ecology has put enormous demands on local authorities, the government, and educational establishments to focus their attention on natural ecosystems.

In accordance with the national strategy of sustainable development of the country, which was adopted in Belarus in 1997, a re-orientation of the environmental protection policy in the country was defined. It was based on the principles and methodological approaches, known in the country as “The twenty-first

century agenda", which were outlined by the United Nation's conference on the environment and development held in Brasil in 1992. Instead of the prevailing earlier direction towards finding and correcting problematic situations, a new series of tasks was put forward. The tasks were aimed at placing environmental protection policy into the perspective of prevention, which is based on the logical prediction or calculation of such situations. At present it is widely known that there are constructive possibilities and a number of opportunities which are exploited to soften the impact and to optimise the prevention of problematic environmental situations from arising. Such possibilities and opportunities include ecological prognosis based on prediction.

Ecological education, ecologisation of society's consciousness have recently become decisive and paramount factors of providing the country's and the world's ecological safety. This will make out one of the major contributions to the process of sustainable development of Belarus.

3. Environmental Education and Sustainability: Cooperation Between the Commonwealth Independent States (CIS) and UNESCO

This Decade directs the spotlight on the central role of education and learning in the common pursuit of sustainable development and also provides opportunity to mobilize the support of the international community to further strengthen the ongoing efforts in improving the quality of teaching and learning. Sustainable development is a moral precept as well as a scientific concept. It is closely linked to peace, human rights and equity as much as it is to ecology or global warming. It also concerns the natural sciences, economics and politics, as well as cultural issues. Founded on values, it implies that we recognize the complex inter-dependence of human needs and the natural environment. It also implies that development goals be conceived not just in national terms, but according to a global vision – as global as our planet. Designated the lead agency for the Decade, UNESCO was tasked with drafting an International Implementation Scheme for the Decade. It is also responsible for coordinating the efforts of governments, educators and students to integrate the theme of sustainable development in educational systems, both formal and non-formal, at all levels. UNESCO also intends to work with civil society organizations, the private sector and the media to help communicate the problems and requirements of sustainable development to the largest possible audience. In addition to performing its international coordination function, UNESCO will develop its own substantive actions regarding education for sustainable development and it will also seek to mobilise sister UN agencies and Member States, as well as other partners to engage with this important issue.

The Decade provides us with the opportunity to work together interdependently, across countries, and across regions so that together we can reach the overall goal which is to integrate the values inherent in sustainable development into all aspects of learning to encourage changes in behaviour that allow for a more sustainable and just society for all. It is a far-reaching and complex undertaking.

Its conceptual basis, socio-economic implications, and environmental and cultural connections make it an enterprise that potentially touches on every aspect of life. The participants here understand better than many the real meaning of the linkages among the social, economic, and environmental arena's of action towards sustainable development that were outlined at the World Summit. For example, the Chernobyl disaster was not only environmental; it also affected the social fabric of much of this region, and had far-reaching economic effects. Education for Sustainable Development is fundamentally about values, with respect at the centre: respect for others, including those of present and future generations, as well as respect for difference and diversity, for the environment, and for the resources of the planet we inhabit. Education allows us to better understand ourselves and others and our links with the wider natural and social environment. This understanding serves as a durable basis for building respect. Along with a sense of justice, gender equality, responsibility, exploration and dialogue, ESD aims to move us towards adopting behaviours and practices that enable all to live a full life without being deprived of basics.

The Decade will promote these ideas by:

- Making people aware that education is a good venue for learning about and promoting a sustainable way of life
- Making sure that ideas about sustainable development are part of schools, colleges, universities and other ways of learning
- Making sure that organisations and governments worldwide work together, so that they can learn from new experiences and from activities in different parts of the world

The Decade addresses the way we live, our values and our behaviour. Because of that, education for sustainable development is not a single subject, but rather cuts across many subjects. It also means that education must be of a high quality, not merely passing on knowledge but changing the way people think. The principles of sustainable development must find their place in children's schooling, higher education, non-formal education, the media, and community-based learning activities. This means education will have to change so that it addresses the social, economic, cultural and environmental problems that we face in the twenty-first century. Along with the preparation of the International Implementation Scheme, UNESCO has clarified the linkages between the Millennium Development Goals (MDGs), the United Nations Literacy Decade (UNLD), Education For All (EFA) and the Decade of Education for Sustainable Development (DESD) to explain the relationships between this new Decade and the educational processes already in existence, as well as provide an overview of the similarities and differences among the MDGs, UNLD, EFA, and DESD initiatives mentioned above.

The World Summit Plan of Implementation agreed to in Johannesburg endorses the Education for All (EFA) goals and makes it very clear that much of the work on education for sustainable development must be closely linked to the pursuit of EFA. It also endorsed the two education-related goals of the Millennium Declaration. The UN General Assembly added the United Nations Literacy Decade to the list of existing educational processes that need to be kept in mind while

developing ESD. Education for All (EFA) and the UN Literacy Decade (UNLD) are not separate events competing for resources. They are mutually reinforcing components of the same movement – a movement to allow people worldwide to fulfil their human rights. Sustainable development cannot be achieved without literate, educated populations, which is why we need to succeed in both EFA and the Literacy Decade. On the other side of the same coin, we will not have reached the goal of a quality education for all unless education reflects a sustainable development perspective in all its aspects – unless a quality education is provided.

Education for sustainable development is a vision of education that seeks to balance human and economic well-being with cultural traditions and respect for the earth's natural resources. It emphasizes aspects of learning that enhance the transition towards sustainability including education of future generations, citizenship education, education for a culture of peace, education that promotes gender equality and respect for human rights, health education, population education, education for protecting and managing natural resources, and education for sustainable consumption. Pursuing sustainable development through education requires educators and learners to reflect critically on their own communities.

In many ways, those who are in privileged positions in societies where consumerism dominates have the most to learn and put into practice about sustainable development. What sets DESD apart from EFA and UNLD is that EFA and UNLD, by virtue of their mission to ensure the right to education for all, mostly address the access needs of all learners – in particular those who are excluded from quality basic education whereas DESD addresses the relevance, the principles, and the values that underlie sustainable development. These differences show that each of the initiatives was set up for a specific purpose. We can sum up the distinctive advantages of each one as follows:

- The MDGs provide a set of clear development goals that we can measure, with education as a significant input and indicator.
- EFA focuses on ways of ensuring that everyone has an opportunity to participate in a quality basic education.
- UNLD concentrates on promoting literacy as a key tool for all kinds of learning.
- DESD promotes a set of basic values, processes and behaviours which should be part of learning in all circumstances.

UNESCO's conceptualization of a quality education is one that promotes and supports sustainability. It includes and goes beyond issues of environmental education, to embrace the more holistic vision of sustainable development that came out of the WSSD at Johannesburg. In particular, it is concerned with application of the principles and ethics that underpin the outcomes of the WSSD. One of the four major thrusts of BSD is to reorient education programmes to include knowledge, skills, values and behaviours related to sustainability in the social, environmental and economic realms of sustainable development highlighted at the WSSD in Johannesburg. Citizens need to be enabled to lead sustainable lives. The understanding of what constitutes a quality education is evolving. There is a demand, however, for education to reflect upon its relevance to the modern world. While in

the past much of the emphasis on education related to cognitive understanding and development, now there is a need to also address the social and other dimensions of learning. Education is expected to make a contribution to addressing sustainable human development, peace and security, and the quality of life at individual, family, societal, and global levels. UNESCO believes that key to the success of the Decade is the acceptance of a wider vision of what is meant by a quality education. For it is through the application of learned knowledge, skills, values and behaviours, outcomes of a quality education, that we can change the way we and others live to ensure a sustainable present and future.

UNESCO's vision of quality is one based in human rights and an understanding of universal human values. It recognizes cultural and historical roots of learning, and knowledge and the realities of the twenty-first century. It believes that these aspects are fundamental to sustainable development. It is a unifying concept that is not uniform. Clearly then, we recognise that the "education" in ESD is not just formal schooling but embraces a wide range of learning experiences and programmes. The focus on basic education and literacy in the orientation of the Decade is important but it certainly does not exclude contributions from secondary education, technical and vocational education, and higher education, or from a wide range of other modalities of learning that may be labelled variously as non formal education, professional development, training, and so forth. Thus, in our conceptualisation of ESD, we would like to capture as wide a scope as possible so that all partners can see how integral and vital their contributions are. At the same time, we believe that such an inclusive approach would serve as a stimulus to improving the quality of education – an education that is relevant to the key problems of living in the twenty-first century, an education that empowers people to exercise their rights, and education that cultivates good citizenship locally, nationally and globally. This great endeavour calls for co-operation and collaboration from the grass roots level upwards, as well as for new and creative forms of partnership. UNESCO is eager to work with governments, academia, associations, NGOs and civil society groups to develop national action plans and to meet the challenges outlined in the Implementation Scheme.

Education for Sustainable Development concerns us all. The ultimate goal of the Decade is that sustainable development must be more than just a slogan. It must be a concrete reality for all of us – individuals, organizations governments – in all of our daily decisions and actions, so as to promise a sustainable planet and a safer world, now, and to our children, our grandchildren and their descendants.

4. Conclusion

The importance of local sustainable development has long been recognised by the international community and reflected in a number of international developments. UN Agenda 21, the guide to sustainable development that was adopted by the UN Conference on Environment and Development in Rio de Janeiro in 1992, emphasises the role of local authorities and local initiatives in supporting sustainable development. Partnership between governments, civil society and the private

sector are now globally recognized as critical to sustainable local development (Bringing Sustainability 2005).

Belarus is a signatory to Agenda 21 and has already implemented a number of activities that show the importance of sustainable development for the country. A National Sustainable Development Commission was established in Belarus in 1996 to coordinate the efforts of different government institutions in the field of sustainable development. In 1997, as pioneer among CIS countries, Belarus adopted a National Sustainable Development Strategy (NSDS). Between 2001 and 2004, UNDP Belarus assisted the government with the elaboration of the new NSDS, which was an exceptional example of close cooperation between state actors and the civil society representatives in Belarus (Halhead 2005).

For successful work on sustainable development, it is important that the local initiatives have access to information and expertise. It is even more important that experience and knowledge are shared between the different initiatives in Belarus and also that exchanges are enabled with similar initiatives abroad (Local Agenda 21 2004).

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THE EDUCATIONAL DILEMMA OF ENVIRONMENTAL SECURITY: HARD SCIENCE OR THE ART OF DECISION MAKING?

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Abstract: Working to overcome twenty-first century environmental challenges requires that university graduates possess a broad range of skills that can not be delivered by traditional university curricula based on the concept of the environment as a subject of 'hard' natural science. This concern poses difficulties for many university teachers in post-Soviet countries (and elsewhere) who see the role of environmental education as a means to provide a platform for sound scientific research rather than to introduce decision-making concepts and tools. The paper discusses the implications of recent socio-economic changes in the post-Soviet region for methodological and pedagogic approaches employed in the universities of the region for teaching environmental studies. Using the example of the changing system of the assessment of anthropogenic impacts on the environment, the paper also analyzes the current problems of the educational system and changes required for it to adequately address the environmental security issues faced by the modern world.

Keywords: environmental education; learning outcomes; skills; teaching methods; learning process; environmental impact assessment

1. Background

The character of environmental education is undergoing transformation worldwide. Specifically, Environmental Studies as an academic subject is being transformed from an individual branch of knowledge that firmly belongs to the natural sciences to the interdisciplinary framework incorporating social science, law, and public policy.

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The field of environmental studies is the study of the relationship between humankind and nature. As such, it is overarching and does not belong to any particular scientific discipline. Currently, environmental studies, and consequently environmental education, is undergoing a *sui generic* bifurcation: obtaining new qualities as an educational platform on which many other applied disciplines now draw. In this new learning paradigm, there is an urgent need to develop and apply teaching methods that will allow the knowledge gained by studies of natural environment to be applied in multidisciplinary subject areas, and to promote teaching of the environment so that the skills of graduates meet the demands of a changing and challenging world.

The environmental field, where decisions often are irreversible and may have national or global impacts, requires the development of both professional and social responsibilities and skills. For Ukraine, a country still feeling the impacts of one of the major environmental disasters of the twentieth century, the nuclear accident at Chernobyl, advanced training in this area with particular reference to openness, transparency and critical thinking applied throughout the decision-making process is of paramount importance.

One way to enable environmental education to answer the needs of a transitional society is to change the attitudes towards course and curriculum design. The change shall ensure the transition from a ***teaching*** process to a ***learning*** process. However, this shift is hampered mostly by the lack of experience of working within the new paradigm. Another challenging task is to introduce crucial changes into curricula content, updating existing courses to state-of-art knowledge and, even more so, developing new, interdisciplinary courses related to the actual problems and decision-making processes in environmental field in transitional society.

This article explores the options available to enable environmental higher education in Ukraine to meet the needs of environmental security by establishing the link between ‘hard’ scientific knowledge and the ‘art’ of the policy development process.

2. Current Teaching Dilemmas in the Environmental Field

The current university educational process in the most cases in Ukraine can be defined as a process of ***studying*** in which the core activity is the transfer of knowledge from the lecturer to the students. The lecturer is a key player in this process: he/she defines the goals of the course and its content based on current practices and regulatory requirements, and chooses forms and methods of teaching, often giving preference to the traditional methods such as lectures and seminars. Students are merely required to absorb the knowledge that is being transferred by fulfilling traditional tasks, such as taking notes in lecture, giving presentations at seminars, and passing exams. Although having sound traditions and merits, such a system is no longer able to cope with the informational flow of the twenty-first century. It is also not able to fulfill the requirements to the modern university education in the field of environmental studies posed by the complicity,

multidisciplinary and universal importance of environmental studies in the modern world.

An educational process aimed at ensuring the ***learning process*** is an alternative to the existing system. In this case, emphasis is shifted from the activities of the lecturer to those of the students. The process, in turn, becomes student-oriented: course content is designed with the consideration of the knowledge and skills already obtained by the students; aims of the course are set according to the students' needs in the context of their chosen professions; methods are selected in order to maximize students' ***learning*** process. The above concept of the university education is well described in the related literature (e.g. Kreber and Cranton 2000; Kuh and Hu 2001; and others).

However, to achieve the transition from studying to learning process in the university classroom will require more than ensuring active student participation in the educational activities. It is also crucially important to change the lecturer's mode of activities to allow such a transition. Problems in implementing the transition are often caused by the lack or absence of experience and of the knowledge of the mechanisms of active learning and of specific methods.

Teaching dilemmas that the environmental educators are most often faced with could be very briefly summarized as follows:

- Information *vs* information skills
- Breadth *vs* depth
- Transferable skills *vs* discipline-specific skills
- Ethical values *vs* 'professionalism'

In addition, the reality of Ukraine's recent transition from a centralized to market economy poses additional challenges that need to be addressed by university environmental education, namely:

- Addressing environmental security and sustainability issues within the socio-economic constraints
- Identifying and prioritizing the most cost-effective environmental mitigation strategies
- Establishing the link between knowledge and action/science and policies
- Providing environmental professionals with effective decision-making tools

All these tasks will require from the young environmental professionals specific skills that are very difficult to be acquired through existing traditional educational approaches.

3. Case Study: Teaching Environmental Impacts Assessment (EIA) in Ukraine

Let us consider the above dilemmas and challenges on the specific case of teaching Environmental Impacts Assessment. *Assessment of the Impacts on the Environment and Ecological Review* is a mandatory course for students seeking bachelors degrees in various environmental programs in more then 20 universities in Ukraine (Borysova et al. 2008). In Kharkiv National Academy of Municipal Economy (KNAME), it is a four ECTS credit course taught to about 70 Bachelor students in

Environmental Engineering and Management in their third and fourth year. The Ukrainian national system of assessing the anthropogenic impacts on the environment is changing and is illustrative of the expectations that the society places on the university education within the environmental field and in other fields as well.

Formal procedures for identifying, assessing, and mitigating the potential environmental impacts of proposed development activities were introduced in the Soviet Union, Ukraine included, in the mid-1980s, in concomitance with environmental regulations being introduced in the European Community and elsewhere in the West. These procedures were further elaborated after Ukraine's independence from the former Soviet Union. Currently, Environmental Impact Assessment (EIA) in Ukraine is a two-tier, state-regulated assessment system. This includes, firstly, the procedure for compulsory assessment of environmental impacts of all new development projects that are classified as having high potential to cause damage to the environment (Ukrainian abbreviation: OVNS). Second, the OVNS materials are analysed by the appointed governmental body, responsible for approval of the project's planning applications, the State Investment Review (*Derszinvestexpertiza*, or *State Integrated Review*). This process includes the analysis of the OVNS materials by regional environmental authorities on compliance with national regulations. Such analysis is called State Ecological Review (SER). The combination of SER/OVNS, along with the provisions for Public Environmental Review (PER) of development proposals, is broadly similar to the EIA model adopted in western countries (UNEP 2002).

4. Key Differences Between Ukrainian and International Systems for Assessment of Human Impacts on the Environment

There are, still, a number of significant differences between the SER/OVNS and the 'Western' EIA. These differences arise largely from the different socio-economic frameworks within which the different systems were developed. The main differences between the environmental protocols developed by the International Finance Corporation (IFC) and the European Bank for Reconstruction and Development (EBRD), the key international investors in the present Ukrainian economy, and the SER/OVNS system, as applied in Ukraine, are discussed below and illustrated in the Table 1. In the following analysis, the 'bank' EIA (or rather, following the recent trends in terminology, the Environmental, Social and Health Impacts Assessment, ESHIA) refers to those requirements developed by these two financial institutions (IFC and EBRD) as well as those based on the Equator Principles, which are, in turn, based on the IFC Sustainability Policy and Performance Standards on Environmental and Social Sustainability (The Equator Principles 2006; IFC 2006).

Overall, there are two main differences between an ESHIA and the Ukrainian practice of anthropogenic impacts assessment: (1) ESHIA is a planning instrument designed to implement a proactive anticipatory approach towards the environment and society, while the SER/OVNS/PER process is a management instrument to justify/reject already taken planned decisions or to mitigate their adverse impacts;

and (2) ESHIA is aimed at preventing and/or mitigating any significant adverse impacts under specific project scenarios subject to pollution control regulations, while SER/OVNS procedures are aimed at ensuring compliance with existing environmental pollution control norms and regulations. First, before continuing to the analysis of the implication of the above crucial differences for teaching and learning processes, let us establish two main reasons why, in principle, the EIA teaching in Ukraine should address the 'western-style' EIA. First and foremost, as has been stated above, the main differences lie not between regulations of the 'western' and 'national' systems, but rather between 'national' practice that follows the technocratic and limited approach inherited from the centralised planned economy and lags behind the national regulations that are constantly being updated (although not always at the pace required to meet the society needs) according to the requirement of transforming economy. Second, the EIA activities in Ukraine may also be carried out at the request of international aid agencies and lenders (e.g. EBRD) and/or according to the country's international obligations (e.g. the Convention on Environmental Impact Assessment in a Transboundary Context [UNECE 1991]).

The impact assessment systems both have the common goal of minimizing any adverse anthropogenic impacts on the environment, but differ from each other in their conceptual approach. These differences are so significant that the two assessment systems could not be used interchangeably. Therefore, Ukrainian projects with western investments, especially those supported by development agencies, may be subject to both the national assessment processes in order to comply with national regulations, and ESHIA to satisfy the investor requirements. However, it is possible to manage both processes so that a positive synergy can be achieved as well as the efficient use of the resources needed for their development. University level environmental education needs to provide the graduates with the skills and knowledge sufficient to fulfil this task. Table 1 summarizes some of the features that differ in the two assessment systems and the learning outcomes that need to be achieved to enable university graduates to function professionally.

It shall be noted that the EIA course is taught in the last 2 years of the Bachelor degree cycle, therefore, in theory, some, if not the majority, of the skills required could have been acquired in the other courses already. However, the comparative analysis of the curricula of Ukrainian and partner European universities teaching environmental studies reveals that exactly the courses potentially aiming into development of interdisciplinary, communicative, team working skills are underrepresented in Ukrainian universities, in particular, in KNAME (see Stolberg 2009). Therefore, there is a need to review the curricula and teaching approaches in order to ensure graduates competence and competitiveness.

TABLE 1. Overview of International and Ukrainian EIA systems and related learning outcomes.

	Ukrainian SER/OVNS	ESHIA	New learning outcomes/skills needed
Screening	Normative screening lists, with virtually no thresholds	Lists with thresholds and significance criteria and case-by-case screening with guidance on significance	Ability to assess impacts significance outside regulatory criteria framework
Scope of the impact assessment	Focus on impacts on the environment (cumulative, social, health, cultural impacts underconsidered)	Integrated assessment of environmental and social consequences, associated projects and cumulative effects	Interdisciplinary skills, ability to team work, incl. team management; ability to develop holistic approach
Impact assessors	State licensed experts	Independent qualified experts	Additional emphasis on professional responsibility and ethics
Impact estimation methodology	Emphasis on approved techniques	Flexible	Personal responsibility for professional decisions
Evaluation of impact significance	Emphasis on institutional recognition (laws and standards)	Institutional, technical and public recognition	Ability to assess impacts significance outside regulatory criteria framework; ability to include ethical values into environmental assessment
Reporting	Part of project documentation, working documents	Stand-alone document	Professional writing skills, ability to communicate technical concepts to non-professional auditorium

5. How Do We Achieve the Reform in Ukrainian Environmental Education?

The approach should draw upon existing significant experience of teaching and studying environmental ***sciences*** in the region, aiming, at the same time, to fill the gap of teaching and studying environmental ***policy***, and working on establishing the currently missing ***link*** between the two.

Curricula in environmental studies at the Universities of the region have seen dramatic changes in the titles of the courses offered to the students, but significantly less change in content and approach. Introduction of new disciplines, based upon integrative cross-disciplinary approaches and a strategic understanding of the interrelation between social and natural processes, is necessary in order to bring the essence of environmental university education in line with societal needs.

In terms of course content, the curricula reform should support exploration of such topics as ***strategic environmental assessment, sustainability appraisal, environmental and social risks assessment and management, environmental implications of European Union enlargement/globalization, and concepts of environmental planning***.

In terms of teaching and learning strategies, the whole range of available approaches should be explored in order to achieve real changes in the higher education in the field. This should include ***active learning strategy, collaborative learning strategy, problem based learning, service education (incl. on-line education), and community based learning.*** The aim is to provide each university with the ability to build its own strategy most suitable to the needs of its institution and students, in a way that adequately addresses the strategic development goals and reflects the best world standards of modern education.

The following steps are recommended on the basis of analysis of best international practice and existing in-country potential:

- To enable university professional self-renewal and development process, drawing on the critical analysis and rethinking of academic knowledge, education content and experience and skills of the most motivated young environmental faculty in the region
- To bring first-hand, cutting-edge knowledge and the most recent development of environmental science and policy to the region by supporting regional and international collaboration of environmental faculty
- To promote application of modern teaching methods in environmental studies in higher education in the region basing on collaborative learning paradigm and linking academic research with in-class activities

On the basis of the above, to solve the ‘hard science – art of decision-making’ dilemma in environmental education demands the development of the emerging interdisciplinary, innovative disciplines.

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LEARNING ECO-EFFICIENCY TOOLS THROUGH UNIVERSITY– CORPORATE COOPERATION

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Abstract: Over the last several decades, the strategies for environmental protection have changed considerably from the implementation of *End-of-pipe* technologies to the implementation of *Beginning-of-pipe* technologies incorporating a wide variety of instruments that are already in use, but are continuing to be developed. Among these technology choices, eco-efficiency tools, such as cleaner production technologies, environmental management systems and material flow analysis, are of particular importance because of their enormous application potential, economic and environmental benefits, and relatively low costs. Implementation of the mentioned instruments fosters the creativity of the human mind with regard to improvements of environmental quality. In the more broad sense, it helps to build capacity for sustainable development and, in the longer time perspective, it helps to motivate technological change. The paper examines an application of eco-efficiency instruments in the teaching curriculum of the Industrial Ecology Department at St. Petersburg State University of Refrigeration and Food Technology. The results of several cooperative projects between the university and food processing companies of the city were put into the research agenda of university students and led to environmental innovations in companies.

Keywords: eco-efficiency tools; sustainable development; material flows; university; company; co-operation

1. Introduction

Sustainable development can be considered as a continuous social process, which unites a strategic pragmatism and questions of ethics and provides time for necessary technological transformation. One of the characteristics of sustainable development is the gradual replacement of environmental protection and optimization with ecological modernization; at this new boundary, processes and systems of consumption and production are introduced (Jansen and Sergienko 2005).

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Many experts have identified the need for further concentration on theoretical substantiation of approaches to sustainable development and a search of new practical tools for that development (Harris and Pritchard 2004). These strategies and tools need to be adopted by practitioners at the different system levels of industrial society. Such adaptation requires new information, data collection and analysis, research and development and decision-making. It is an evolving learning process itself. The number of these tools continues to increase rapidly. At present, the most developed and widely-used eco-efficiency tools include environmental management systems, cleaner production methodology, material flow analysis, life cycle assessment, eco-labeling and eco-design. Finally, a social dimension of sustainability is also bringing its instruments, such as sustainability balanced scorecards, corporate social responsibility checklists, etc. To researchers, it seems at times that some of these tools and approaches are impractical and can contradict each other. However, systemic studying of basic principles and requirements of sustainable development shows that these tools do not compete, but rather mutually supplement each other and, in aggregate, can give an absolutely unexpected push to development of sustainable strategies.

2. Sustainable Development, Eco-efficiency and Its Tools

For the last decade, some tools for management and monitoring of sustainable development have received world recognition. Cleaner production and ISO 14001 models, the life cycle assessment, ecological footprint indicators, the Factor 4 and Factor 10 concepts are well known and are used in a wide variety of settings. These tools are developed and supported by many international organizations and programs (Weiss and Bentlage 2006). The development of tools forming the methodological basis for sustainable development was introduced by experts from Germany, Austria and Finland, who, in particular, have demonstrated the benefits of indicators of material and energy flows in economic systems at national and regional levels and within firms (Sergienko and Rohn 2005). Environmental contamination does not adhere to any spatial boundaries. Life cycle analysis (LCA) examines the entire lifecycles of the products including the extraction, moving and transformation of the natural resources necessary for production, and disposal of end products. Humankind cannot exist sustainably if anthropogenic cycles continue to proceed in the same manner as they are now. Experts of the German Wuppertal Institute, who developed the concept of eco-efficiency, believe that at least two planets will be required to provide the natural resources demanded by today's society in the near future (Ritthoff et al. 2002). The Wuppertal Institute for Climate, Environment and Energy, created as a research center in 1991 in Germany, explores material flows from the extraction of raw materials to final disposal, calculating their global «ecological rucksacks» and the extent of land use involved. It develops concepts, strategies and instruments aimed at improving resource productivity and sustainable resource management (Wuppertal Institute).

Basic mechanisms that can be implemented to achieve sustainable development include: dematerialization (reduction of the quantity of material flows in the

economy), trans-materialization or replacement (change of the types or quality of material flows used), and suspension and close looping of material flows (Sergienko and Rohn 2005). These mechanisms can be applied separately or used at different levels of management simultaneously, thereby strengthening each other. For example, changes can address specific quantity and types of fuel and energy resources used or changes can address the whole processes, such as resource reduction or the implementation of more ecologically safe and socially responsible technologies, while continuing to satisfy human needs.

There are established techniques used to consider the hidden resource streams or total material flows arising in product life cycles. For a given enterprise, technological process or product or service, a specific Material (or resource) Intensity of a Product or Service (MIPS) is used to evaluate the technological operation or production of that product. Information on Material Intensities can be found atwww.mips-online.info (Wuppertal Institute). General principles of MIPS-analysis are emphasized on produced goods or rendered services, as well as on orientation to human needs and life quality, whole life cycle assessment of a product and account of efficiency of production or services (Ritthoff et al. 2002). MIPS-analysis and Factor 4 (or Factor X – in general) are the tools of eco-efficiency. The notion of "eco-efficiency" reflects an idea of getting a lot of offering products or services for the least costs and the minimal expenditure of all kinds of resources or by its maximum effective usage.

Life cycle assessment (LCA) and other eco-efficiency tools have been criticized for their uncertainties, which are inherent to all models (Hammer et al. 2005). As the basic principle of additives says: there is not only one language, but rather many different languages that serve to complement each other (Moiseev 1999). No complex system can be described by one model. Therefore, a set of tools is needed. Since our knowledge and thought processes are highly rational, new ways of thinking and scientific methods are developed very slowly. Therefore, networking is needed.

3. Availability of Tools and Their Choice: Some Information and Communication Gaps

In order to support sustainable development, relevant environmental policy is needed. Environmental education, as well as information and communication, policies should become components of that environmental policy for eco-efficiency. This shift should be towards not only education and research, but also towards spreading and exchange of relevant information and data. Although there are already many eco-efficiency tools applicable in Russia, only a few of them are known and currently in use. While the results of eco-efficiency studies have not yet been discussed by a wide Russian audience, they are accessible in the academic circles in higher education establishments due to growing information exchange and networking. Therefore, these information and communication gaps could hopefully be partially closed by promoting cooperation between universities and companies.

As recognized in the Rio sustainable development process since 1992, economic, environmental and social dimensions of society should become supported by relevant education policy focused on the creation of a basic capacity for environmental education aimed at sustainable development (Sergienko 2004) that includes both content and methods. In terms of a quality of the environmental educational process, it is reasonable to link the basic capacity for sustainable development with availability of the following resources:

1. Prepared instructors able to teach the best practices, for example, best available technologies, eco-efficiency tools, etc. (*Man*)
2. Motivated students (*Material*)
3. New teaching methods (*Method*) and
4. Information exchange by networking between universities and companies (*Machine*)

In higher education, the new non-conventional teaching methods demand the development of knowledge and skills in the field of web-resource use, creative decision making, and effective communication. Such methods should be combined with research for local or national companies. This is also attractive to the companies financially. Therefore, the innovative system for practice-oriented research and development in regional or local conditions is needed.

This system in practice is a cooperative network, which should include foreign partners, educational and research institutions and other companies. In order to identify business needs, additional sources should be supplied for partners' research, testing, measuring and product development needs. Research and development (R&D) projects should be focused on resolving practical problems by implementing eco-efficiency tools. Therefore, the famous Deming Cycle, based on the so-called "Plan, Do, Check, Act" total quality management model in the 1950s, could be changed to meet the growing education, information and communication needs of the Russian society (Weiss and Bentlage 2006) (Figure 1).

The effective technique of *learning by doing* that is grounded in networking, planning, implementing, and pursuing corrective actions, will allow for continual improvements in ecological efficiency in partner companies.

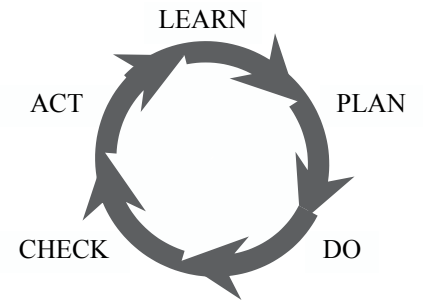

Figure 1. Model of continuous learning.

University-led R&D projects to estimate material intensity of new products and processes are necessary. In the agriculture and food sector, the research should be carried out for basic products such as animal feeds and fertilizers. In all industrial

sectors, energy production, transportation, infrastructure and its relative contribution to the overall production material intensity need to be investigated by means of cooperative networks. Thus Factor X improvements in all sectors of the economy could be examined.

4. Possibilities for Learning Within University – Corporate Cooperation

Possibilities for learning eco-efficiency tools in universities-companies cooperation were investigated in the frameworks of several Finnish-Russian projects held in 1998–2002 in St. Petersburg. Then, such cooperation was continued within the project "Improving eco-efficiency in the North-West Russia" implemented under support of TACIS CBC Program in 2002–2004. TACIS CBC is an abbreviation of the name of the European funded cooperation program – Technical Assistance for CIS countries (of the former Soviet Union) for Cross-border Co-operation Projects. In this particular project, experts from Germany, Finland and Russia took part. For this project, a team of experts of Wuppertal Institute and Trifolium Company, Germany, Environmental Technology Center Neopoli, Finland and APILA Network, Finland shared their expertise in the field of sustainable development and eco-efficiency. Among the project target groups were teachers and students of St. Petersburg State University of Refrigeration and Food Technology as well as employees of the eight food companies of St. Petersburg (Sergienko 2005).

The overarching goal of the project was to examine international experience of eco-efficient management and benefits of its application to conditions in Russia. Distribution of information and transfer of knowledge in the field of eco-efficiency

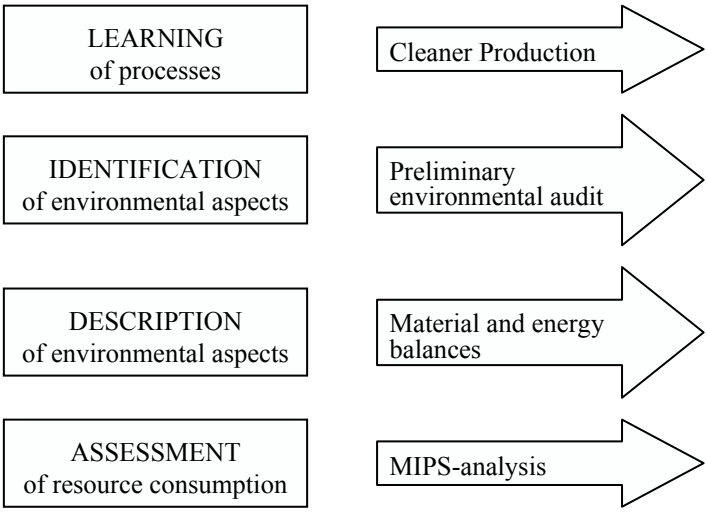

Figure 2. Integration of eco-efficiency tools in universities – corporate cooperation.

tools, research of existing environmental management practices and introduction of actions for improving eco-efficiency within food enterprises were considered as the main tasks of the project.

To achieve the project goals, focus was on integration of such eco-efficiency tools as cleaner production and environment management systems, international standard ISO 14001, eco-balances and MIPS-analysis (Figure 2).

Project activities included lectures, small group works, work in companies under preliminary environmental audit and cleaner production assessment, expert and student visits to companies, study trip to Finland, projects' development and implementation.

While conducting the preliminary environmental audit, the most important environmental aspects of the companies were identified with cooperation of students, teachers and company personnel. Both students and young researchers took part in defining the general legislative and normative requirements and the companies' conformity to those requirements, analyzing existing practices and procedures of environmental management, allocating duties and resources, and comparing environmental management practices with the requirements of ISO 14001 standards.

In addition, factors influencing implementation of cleaner production and other eco-efficiency tools in the Russian enterprises were analyzed, and strengths and weaknesses of the existing practices of environmental management systems were investigated.

Students, teachers and companies' employees have studied the MIPS-concept or FACTOR X, and results of the Russian Material Inputs (MI) –calculations are shown in the Table 1. Material inputs or total material inputs, including those materials, which required energy for its production, were calculated by students on the basis of data provided by companies.

TABLE 1. Results of the Russian MI-calculations in 2002–2004.

Product/service/substance	$MIPS_{RUS}$
COMBINED HEAT and POWER ENERGY	
Heat energy (production stage only)	0.27 kg/kWh
Heat energy (production stage only)	0.37 kg/kWh
CHEMICAL SUBSTANCES	
Nitrogen, liquid	0.29 kg/kg
FOOD STUFFS	
Meat products	35.5 kg/kg
Vodka	3.44 kg/kg (2.18 kg/kg – if bottles are recycled)
Wheat bread	1.8 kg/kg
Ice-cream	4.92 kg/kg

After the project's end, MI-calculations were continued in 2004–2005 within students' research and diploma work. Since 2005–2006 academic years until recently, students of the Industrial Ecology Department calculated MI-values within the Life Cycle Assessment course in the University curriculum (Table 2)

and as part of their diploma requirements. Our cooperation with companies continues both by means of projects and students summer internships. At present the department has agreements with more than 20 food companies of St. Petersburg for the organization of student work and training in companies. During the internships, the students identify environmental problems and then solve them by using any eco-efficiency tools from the existing and known toolkits.

TABLE 2. MI-calculations in 2004–2007.

Product/service/substance	$MIPS_{RUS}$
COMBINED HEAT and POWER ENERGY	
Heat energy (production and delivery stage)	0.53 kg/kWh
Power energy (production and delivery stage)	0.71 kg/kWh
WIND ENERGY	
Power energy (production and delivery stage)	0.10 kg/kWh
FOOD STUFFS	
Rye bread	1.65 kg/kg
Wheat cake with raisins	11.11 kg/kg
Smoked herring	0.53 kg/kg
Canned forest berries with sugar	15.9 kg/kg
Quickly frozen forest berries	0.13 kg/kg

The results of the calculation work are presented in some publications in Russian (Sergienko 2004; Sergienko and Rohn 2005).

At the meat processing company located in St. Petersburg, Russia the students calculated an increase of eco-efficiency of the production after the modernization of heat pipelines. Several combinations of thermal isolation materials were analyzed. The purpose of the project was to reduce the heat loses to the environment and maintain the required parameters of heat-carriers to consumers and safe conditions for the employees. The MIPS-analysis showed that the most effective type of thermal isolation was a combination of mineral-wadding cylinders Rockwool and glass fiber. The modernization allowed for the achievement of FACTOR X equal to 2.2 and the net present value of US$55,000 for 10 years of operation. The required investments are paid back after 2.15 years (Sergienko 2004).

5. Conclusions

The process of updating production systems is complex and demands adequate management, development of ecological consciousness and ecological and social responsibility connected with the development of social participation. This process proceeds by involving all interested parties in a dialogue for development of the policy directed towards technological updating. In the changing world there is not one common way and one type of tool for improving eco-efficiency, and an

exchange of experience in training and informing in the field of eco-efficiency is necessary. Creating the basic capacity of environmental educational process for sustainable development is a long-lasting process. International cooperation and universities-companies cooperation can substantially enhance it.

For this purpose, universities of applied sciences should continue to specialize in practice-oriented research and development in their fields strengthening the preconditions for sustainable eco-efficient development of local industries.

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MODERN APPROACHES TO SUSTAINABILITY AND SPATIAL DEVELOPMENT: EDUCATIONAL ASPECTS

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Abstract: Today we are not talking about sustainable development alone, but also about its spatial understanding. This new vision of sustainable development is shaping the modernization of the educational process, which takes the transformation of traditional approaches to modern requirements into consideration. Traditional theories of spatial development basically examine it in a *two-dimensional* (i.e. territorial) aspect. Generally speaking, the systems' stability or sustainability is a measure of its ability to keep movement, or changes within the system, on the intended trajectory, despite the influence of outside forces. The three forms of stability, inertness, recoverability and plasticity, will be discussed in this paper (Grodzinskiy 1993). The modern approach to understanding the ***spatial sustainability of a system*** should be based on the ability of the system to meet these forms. This paper will also discuss the properties that each element of a system must have in order for the system to model special sustainable development. The up-to-date educational process should be focused on new understanding of management for sustainable development and on corresponding sets of tools.

Keywords: spatial development; spatial sustainability; spatial management; environmental policy; education

1. Introduction

The modern view on development, including qualitative and quantitative elements, is, to some extent, associated with the concept of sustainability. Nowadays, we are also talking about the spatial understanding of sustainable development. This new vision of sustainable development involves understanding the modernization of the educational process on the basis of transformation of traditional approaches to modern requirements.

This paper presents a general idea about the modern approaches to sustainability as an integral part of societal progress and to spatial development as a new and satisfactory component of the development methodology of understanding,

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researching and organizing the educational process. The idea is based on six general steps to identify the educational aspects of modern approaches to sustainability and spatial development.

2. The First Step

The ***first step*** is to clarify our understanding of definitions. Traditional theories of spatial development basically examine it in a two-dimensional (i.e. territorial) aspect. Generally speaking, the systems' stability or sustainability is a measure of its ability to keep movement (or changes of a system) on the intended trajectory, despite the influence of any internal or external factors.

There are three forms of stability (Grodzinskiy 1993):

1. Inertness – the ability of system at impact of the factor f to not leave the set area of conditions z_0 during the time Δt
2. Recoverability – the ability of system to come back in time Δt to the area of conditions z_0 after being outside the area under influence of the factor f
3. Plasticity – the existence of several states of system conditions (z_0) within set limits (Z) and the ability of system to move under the influence of factor f from one state to another, remaining within the limits Z during time Δt.

The modern approach to understanding the spatial sustainability of a system should be based on the ability of a system under the influence of external factors to remain or revert to one of areas of conditions due to inertness and recoverability, or move owing to plasticity from one state to another and remain within set limits during a set interval of time.

3. The Second Step

The ***second step*** is to analyze the present situation and general tendencies of development, emphasizing the educational aspects of the process. The spatial approach allows for estimating processes, factors and interrelations of social, economic and environmental-economic development for achievement of adequate common stability in a multivariable coordinate system. It should be noted that one of the basic vectors of research should be connected with the phenomena of time in socio-economic, environmental, cultural-educational coordinates.

Today, spatial development supposes three-dimensional research, including time as the third dimension. In modern times, we are using the phrase "time compression" to refer to a new phenomenon of our perception of the world where all processes are accelerating due to the progress of science and technology, development of information and computer technologies, and simplification and activization of migration processes. "Time compression", in conditions of globalization, allows estimating phenomena of development (educational, organizational, informational, etc.) with other points, efficiency of "reaction" and an opportunity for "introduction". Nowadays, globalization benefits less than half of mankind, and many states/territories that are not in the condition "to catch up" begin to slide on

a "pole of decline" (Inozemcev 2000) and cannot exist as independent states. These are the states of the Central and Northeast Africa, Southern Asia.

The dimension, time, should include an understanding in heterogeneity and discrepancy of its current, dynamics of its influence on economic parameters, teaching system and development as a whole. Already it is possible to speak about social and educational phenomenology of time due to:

– Fast changes of management conditions and criteria of efficiency
– Capital virtualization (rapid development of financial markets all over the world, strengthening the dollar as worldwide currency, growth dependence of countries economies from fluctuation and unsustainability of the other markets) and economic expansion by spreading the private capital and bank systems
– World-wide information net
– Virtualization of education (spreading the reach and scope of education, impersonal examination and knowledge test, etc.).

4. The Third Step

The ***third step*** is to single out implementation properties and principles of spatial development and spatial management. Spatial sustainable development is possible under the conditions that each element has the following properties:

- Ability to interact with the other components of the system
- Orderliness and structuredness of interrelations, i.e. presence of precise mechanisms of interaction
- Integrity, uniqueness and independence of each element
- Existence of three basic groups of the factors causing spatial development: "input", "output" and interrelations between them.

So, the up to date educational process should be focused on the new understanding of management for spatial sustainable development and corresponding sets of tools. Spatial management is the conscious activity of determining a spatial strategy for balanced environmental socio-economic development, working out priorities, forms and methods of the special system's functioning (Pavlikha 2001). The aim of spatial management is to achieve the simultaneous maintenance of increasing standards of living, rational use of territory, natural resources and environmental protection.

The basic principles of spatial management are:

- Achievement of territorial unity through balanced social and economic development, including improvement of their competitiveness
- Control of the physical expansion of towns and cities (ESDP 1999)
- Mixture of functions and social groups (which particularly applies to large cities in which increasingly large sections of the population are threatened by exclusion from urban society)
- Wise and resource-saving management of the urban ecosystem (particularly water, energy and waste)
- Better accessibility by different types of transport which are not only effective but also environmentally friendly

- The conservation and development of the natural and cultural heritage
- Restriction of influence of natural disasters.

5. The Fourth Step

The ***fourth step*** is to determine role of education among other components in realization of principles of sustainable development and spatial management. Realization of conceptual positions of sustainable development, irrespective of a hierarchical level of space, is carried out through legal, organizational, financial and economic, educational-scientific and educational-information components of the mechanism.

- The legal component of the mechanism represents the system of laws, documents and the procedures forming a legal field of sustainable development. It is system of the current legislation, concerning distributions of authority and the responsibility between executive authority and institutions of local government. It is presented by the Constitution of Ukraine, Laws of Ukraine and other statutory acts regulating the decisions regarding various problems of economic, social and ecological character at a regional level.
- The organizational component is a system of establishments, organizations and services which are carrying out the basic functions of effective regional management. The given mechanism includes the state strategies of regional development, development of republic and separate cities, territories, program documents, various plans and forecasts of development (Zharova 2005).
- The financial and economic component of the mechanism of sustainable development of territory is a system of industrial divisions and economic relations, determining a ratio between proportions of production and consumption of goods and services, and also an opportunity of financial maintenance and stimulation of sustainable development of territory.
- The educational-scientific component includes a combination of educational and scientific knowledge and methods. It includes divisions generating new knowledge and ideas and providing a professional training for sustainable development strategy. It provides the possibility of full and effective involvement of scientific personnel in the region.
- The educational-information component includes organizations and communication. It includes gathering, processing, sharing and explaining information to authority and stake holders. The information should not only reflect changes of economic growth and demographic tendencies, but also reflect the conditions of the surrounding environment and probable consequences of these changes. Another main point is teaching stake holders to understand, interpret, use and share this information.

6. The Fifth Step

The ***fifth step*** is scanning up-to-date sets of sustainable spatial development tools for appropriate educational, planning and organizational purposes. The mechanism of effective realization of politics, plans and programs of sustainable spatial development within the limits of the state, which have essential regional features, includes the following components:

- System of government and support of strategic branches
- Various forms and sources of indirect stimulation (i.e. employment assistance, offer/proposal conditions, financial preferences, etc.)
- Methods of stimulation of innovative investment potential
- Up-to-date educational programs.

At the same time, the mechanism can be effective only under concrete objective estimations of socio-environmental-economic conditions in the country, region and branches and problems and prospects of its development in a context of nation-wide priorities. In fact, spatial/territorial systems are open-ended and developing in national, universal space. Thus the examination of sustainable spatial development is necessary, and the mechanism of maintenance of stable development should be constantly improved and supplemented with new elements.

We speak about Strategic Environmental Assessment (SEA) as a vector of application of the organizational and educational efforts that are capable uniting requirements of time, economic efficiency and social stabilization (the influence of a society on decision-making and reflection of results in normative and supervising documents). Mobility and an openness of procedures allow us to speak about other approaches to the formation of politics of spatial development where the coordination of interests is costly in management efficiency (Khlobystov 2005).

7. The Sixth Step

The ***sixth step*** is resuming. The environmental problems facing the whole of mankind as well as concrete countries, regions, cities and branches require immediate and resolute actions. One of methodical approaches to sustainable development of the socioeconomic system includes the creation and realization of systematic approach or methodology, which will provide general purposes and possible scripts of development, selection criteria for the most suitable approaches, and the realization of management operations that will lead to the achievement of purposes and scripts to continue development.

8. Conclusions

The presented six steps for identifying the educational aspects of modern approaches to sustainability and spatial development (accurate definition, analysis of the present situation, formulation of principles of spatial development, determination

of the role of education among other components, the scanning of up-to-date sets of sustainable spatial development tools, resuming) allow us to draw the following conclusions:

Previously, decision-making management of environmental-economic systems was carried out based on a simple algorithm: the information – action – result. Today's representation of a problem and modern administrative concepts transform this previous algorithm to the closed cycle: the information – action – result – the new information leading to continuous analysis to find more productive action.

We consider the SEA to be the uniting element of the general mechanism of spatial sustainable development, which meets modern requirements, global tendencies and obligations of Ukraine and also has sufficient base for introduction in the country. This tool can not be ignored in the educational process as it allows for the creation of a new generation, one that is ecologically conscious and economically successful.

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A COMPARISON OF ECOLOGICAL EDUCATION AND SUSTAINABLE DEVELOPMENT EDUCATION

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Abstract: An education for sustainable development aims to: (1) promote knowledge about the environment and its condition; (2) provide criteria, standards and recommendations for decision-making regarding the preservation of the natural environment and comprehensive solutions to social, economic and ecological issues; (3) demonstrate the possibilities for economic development while preserving the environment; and (4) increase the importance of ecological traditions and ecologically sensible means of running the economy in order to foster environmental stewardship. An education for sustainable development involves the study of the conditions of balance of social-natural systems, equilibrium planning and sustainable management of territorial units, resources and economies. Recently, the use of the concept of sustainable development has been gaining momentum due to the prospect of reaping economic and political dividends from its implementation. This paper will outline, in detail, what an education for sustainable development is and how it differs from ecological education; this is a crucial distinction considering current, pressing environmental issues.

Keywords: ecological education; sustainable development; environment; economic development; nature, society; anthropocentric; ecocentric

1. Introduction

The concept of sustainable development is a reaction to the crisis which originated from the inability of society to adapt to a rapidly changing environment, the loss of capacity for regeneration and ineffective environmental management. The only way to solve this crisis is to change the interaction between nature and systems created by man, reform the social system and management as well as the theory of development, and introduce sustainable management practice. Thus, education for

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sustainable development differs from ecological education in that it is based on the idea that the current environmental issues (green-house gas emissions, persistent organic pollutants, degradation of arable land, etc.) are more a managerial issue rather than an ecological one.

In a broader sense, the major goal of education for sustainable development is to promote the emergence of a widely educated and socially involved individuals capable of understanding the new phenomena and processes of social life and having various perspectives, ideas and a cultural and ethical code as well as behavioral traits, which will ensure preparedness for socially responsible activities and the continuation of education in constantly changing world (Danielidze and Sargsyan 2004).

2. The Ecological Education Model

The objectives of ecological education are interwoven with the general educational objectives of comprehensive development of an individual and creation of conditions for self-realization. An ecological education achieves these objectives through the specifics of its interdisciplinary content and experiential methods.

One of the basic concepts in ecological education is the interaction between nature and society. This concept integrates anthropocentric and ecocentric approaches (Gevorgyan et al. 2006). While addressing human behavior in the natural environment and attitudes towards living creatures, we often are equating ecological education and cultural education. Indeed, if by cultural education we mean world outlook, morale, law, knowledge, skills, intellectual level, and the ways and means of communication between people, then the terms "ecological education" and "culture" almost converge. Targeted work in ecological education of children has been done in Armenia for more than 25 years (Danielyan 1996). It is difficult to confirm any improvement in the condition of environment in such a time period. One of the key obstacles is the public perception of ethics and preferred way of life. Ecological values such as clean air and water are considered primarily through an individual's perspective of personal comfort, which is a very high priority for most people. That is why we are more willing to install filters on water taps in our apartments rather than solve the larger ecological problem by reducing the dumping of waste into a nearby river. Hence, we must greatly rely on ecological education with the hope that it can influence the system of values of future generations.

"Think globally, act locally …", the famous saying of the modern French biologist Rene Dubos, became the tag line of modern ecological education (Danielidze and Sargsyan 2004). How do we understand the call for local action? Unfortunately, instead of focusing on identification and solutions of ecological problems, an ecological education consists of auditorium lectures and observation of the natural environment. Obviously, in order to act, we first need to understand the processes unfolding in the environment. If we truly want to make ecological education effective, then the professors should teach the students not only about ecological problems, but also about their roots. Professors should teach the

principles and approaches required to seek solutions and present action plans to resolve identified problems. Such an ecological education facilitates the creation of a social foundation to implement the concept of sustainable development (Zhevlakova et al. 2005).

While reflecting the ambiguity in perception of nature and society, the objective of ecological education is also twofold. From the anthropocentric perspective, the objective is the attainment of competence required for the adjustment of an individual to the changing structure of risk determined by the state of the environment. From the ecocentric perspective, the objective is the facilitation of a responsible attitude towards the environment, which implies adherence to some kind of ethical norms and standards. However, we still do not have those norms and standards of human behavior with respect to land, animals and vegetation. If traditionally ethics is thought of as the line between socially accepted and unaccepted behavior, then in the ecological sense it should be the "limitations on the survival struggle". What is the connection between ethics and ecological education? Despite the age-old propagation of environmental protection, there is not much actual progress. In Armenia, the work in this direction is mainly limited to ambitious documents and traditional rhetoric.

There is an opinion that the objective of ecological education is to increase the ecological culture of an individual (Zhevlakov et al. 2005). However, ecological education is based on the transfer of knowledge of fundamental and applied ecology to students. The increase of cultural consciousness should be primarily attained through transfer of scientific knowledge. Additionally, culture implies not only knowledge, but also a high level of intellect, behavior, the ability to interact and cooperate, the ability to feel and understand people and nature, concern with the state of the environment and the zeal to resolve ecological issues. We cannot rely only on fundamental and applied ecology to achieve the aforementioned objectives. On one hand, the increase of ecological culture, i.e. ecological awareness and responsibility, is not possible without knowledge about society and environment. On the other hand, since there are not any purely ecological problems, all of them have social and economic causes; the society cannot escape the need for study of social and economic disciplines.

3. The Sustainable Development Education Model

An analysis of content and organization of ecological education suggests that, in the second half of 1980s, the objective of ecological education in Armenia was the formation of ecological culture (a code of behavior when dealing with the environment) and the advancement of concern for the protection of the environment. In the early 1990s, priority was given to fostering responsible attitudes toward the environment and the emergence of systems thinking. Recently, Armenia adopted a new approach due to the emergence of the new concept of sustainable development which significantly influenced the thinking of people about the further paths for development of civilization. In order to implement the concept of sustainable development, it is first necessary to tackle the issues of high birth rates, especially

in least developed countries, regulate the use of natural resources through introduction of international taxes, restore the destroyed and damaged ecosystems and reduce military involvement (Vargatov and Andreeva 2001). Obviously, numerous social, economic and ecological problems need to be solved. Although we can easily present what needs to be done to achieve sustainable development, it is quite complex to provide advice on how to implement it (Armanov and Bilkina 2003).

An education for sustainable development should aim to: (1) increase knowledge about the environment and its condition; (2) provide criteria, standards and recommendations for decision-making in the field of environmental protection and comprehensive solutions to social, economic and ecological problems; (3) demonstrate economic development possibilities while preserving the environment; and (4) enhance the importance of ecological traditions and ecologically feasible ways of running the economy in order to foster the care of various countries for environmental heritage.

More specifically, the objective of an education for sustainable development is to assist individuals in acquiring both knowledge and experience, and developing creative skills and self-realization to emerge as a truly socially integrated individual in the process of defining a comprehensive solution and preventing social, economic and ecological problems. The specific objective of education for sustainable development also aims to promote the improvement in the quality of life of current and future generations. However, the ecological education has a unique, specific mission, i.e. to ensure adherence to ethical norms and standards (Gevorgyan et al. 2006). This is the reason why models effective for other disciplines are not sufficiently effective when it comes to ecological education because those models do not delineate between socially and ethically acceptable and unacceptable behavior, do not propose any commitments and do not introduce changes into the existing system of values.

4. Conclusions

The interdisciplinary nature of ecological education should be viewed in a broader context than merely interrelations of concepts from biology, geography and other natural sciences. Recently, the idea of sustainable development became quite attractive and politicians and economists started cashing in on it. Yet, there is not a clear understanding of what an education for sustainable development is and how it differs from ecological education. Education for sustainable development differs from ecological education in that education for sustainable development is the idea that the current environmental crisis (greenhouse gas emissions, increasing degradation of arable land, persistent organic pollutants) is more a managerial issue rather than an ecological one. Sustainable development is the reaction to the crisis which stemmed from the inability of society to adapt to a rapidly changing environment, the loss of capacity for regeneration and ineffective management of natural resources. A change in the way interaction takes place between the natural environment and systems created by man is required. By inference, we can state

that reform of management, development theory and sustainable management inception is also required. An education for sustainable development includes the study of the conditions for stability of social-natural systems and a balanced and sustainable management of territorial units, resources and local economies. This involves a balance between developed and developing countries (such pervasive phenomenon as anti-globalization and international terrorism should be viewed as a reaction to un-equilibrium). Sustainable development concerns the balance of interests between governments and businesses, between the needs of current and future generations, and between traditional use of the environment and new technologies. And last but not least, sustainable development concerns the balance between economic, social and ecological factors when discussing any social-natural processes in a modern rapidly changing environment.

Do we need to discard the ecological education and embrace only the education for sustainable development? We should abstain from radical measures. The subjects of study within ecological education and education for sustainable development do differ. Ecological education will continue to exist. It is only ecological education that will ensure an understanding of ecosystem processes, an increasing ability to feel and understand nature, a nurturing of a careful attitude towards nature and concern about its condition, and a lasting commitment to resolve social and ecological problems.

Ecological education and education for sustainable development ought to develop in tandem. Sustainable development can be viewed both as a framework and a separate subject. As a separate subject, sustainable development can be taught in middle and high school with a preliminary background in the field of ecological education. In high schools and specialized pre-university education institutions as well as universities, the emergence of sustainable development as a separate subject can be attained through a series of courses related to environmental studies and issues of managing social and natural systems.

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PART II. EDUCATIONAL NEEDS FROM THE PERSPECTIVE OF EMPLOYERS AND PROFESSIONALS

THE ROLE OF TRANS-DISCIPLINARY SKILLS IN ENVIRONMENTAL EDUCATION AND SCIENCE

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Abstract: In the past four decades there have been tremendous changes in how environmental scientists address issues relating to societal needs. In the early 1980s, interdisciplinary work involved one or two related science disciplines in combination to evaluate national issues. As the success of interdisciplinary environmental science efforts was demonstrated and institutional boundaries were successfully crossed, great institutional progress was made. Many universities created Biological Science or Environmental Science Departments or even Schools and began to smear or fully obliterate some long-established disciplinary lines. However, Interdisciplinary Ph.D. graduates were scarce or not necessarily encouraged and leaders in these new efforts were generally those from disciplines that relied, inherently, on interdisciplinary perspectives. Now, in 2008, with the general movement to recognize the importance of ecosystem services to society and to value these services from the perspective of human well-being, another threshold looms that requires a trans-disciplinary perspective. The rewards to individuals as well as society in developing functionality with respect to trans-disciplinary approaches are many and essential to continue to make progress in understanding and solving environmental problems that continue to become more complex.

Keywords: ecosystem services; environmental education; environmental security; social-ecological networks

1. Introduction

As an elementary student in the 1950s and through undergraduate university work in the late 1960s, my science education was strictly compartmentalized along disciplinary lines. Discussions with colleagues in Europe, Australia and what is now Russia indicate this was their experience as well. The one class I took as an undergraduate that had a broad interdisciplinary perspective was limnology

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(Ruttner 1953). This early text explained how biological and chemical attributes of lakes are driven by and intertwined with physics and geology. Immediately, limnology provided the biophysical context for understanding the environment and very directly linked and cross-linked math, physics, chemistry, meteorology and biology in tangible and visible ways.

It was difficult to determine where limnology should reside in a university setting of the 1950s–1970s. The professional focus of the limnology professor usually dictated a physics, zoology or even botany departmental affiliation – awkward at best and not indicative of limnology's interdisciplinary nature. However, these rigid science lines were about to be obliterated as a result of a series of important disclosures regarding environmental degradation due to human activities. The environmental consequences of direct and widespread chemical usage was documented and explained to the public in a book of immense impact, *Silent Spring* (Carson 1962). In the United States, societal awareness of environmental problems, perhaps of a more tangible and interdisciplinary nature, emerged with the recognition that lakes and streams were immensely and negatively impacted by human point discharges of municipal waste (NAS 1969). This eutrophication clearly resulted in fish death, undrinkable and unswimmable water that often was discolored and odorous. The broad geographical impact of humans on the environment was further demonstrated by the slow recognition in the 1980s that acidic precipitation originating from far distant sources could have severe impacts on sensitive ecosystems through atmospheric transport and deposition. Understanding the complex phenomenon of acid rain forced scientists to develop close interdisciplinary liaisons that now linked terrestrial and aquatic biological systems with the atmosphere through chemistry. In turn, universities began the slow transition of creating new integrated departments and schools to foster closer collaboration among disciplines and to provide society with the complex understanding and solutions that these complex problems required.

All of the preceding environmental concerns are still with us in various stages of containment or abatement around the world. And, of course, there are many more that I have not discussed. In some locations, although the degradation is recognized, little is being done from the remediation perspective. On top of these local to regional environmental problems, global climate change has become recognized as an even broader, global threat, mediated by human activities. Together, this series of major environmental concerns has driven what had been isolated scientific disciplines to work together toward understanding and possibly solving these threats to the earth's ecosystems on which humans are entirely dependent. For science and society to make further necessary and possibly urgent progress, educational changes from elementary through graduate and professional schools are needed.

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2. Forced and Voluntary Interdisciplinary Collaboration

Recognizing that acidic deposition could result from burning coal containing high sulfur content and that the distance from the source to the place of unequivocal impact could be measured in hundreds, if not thousands of kilometers, had direct impact on science and science education. When the National Acid Precipitation Assessment Program was authorized in 1980 by federal law (Public Law 96-294) in the United States, 12 government agencies began a mandated (i.e. forced) unconventional 10 year period of collaboration to understand the nature of acidic precipitation and the extent of its impacts. Early efforts to implement new, innovative, interdisciplinary approaches (Landers et al. 1988) that combined statistical probability sampling of lakes and streams with new indicators of condition to develop rigorous estimates of the number and area of freshwater systems susceptible to and possibly effected by acidic precipitation were initially met with strong opposition. As years passed, the strengths and merits of these new approaches became documented in the scientific literature and, even more importantly, the resulting data were used to influence policy and legislation. The major institutional impact of this work was the broad subsequent application of probability surveys and indicators of conditions to evaluate and track the status of the nation's aquatic resources, by the United States Environmental Protection Agency (EPA) (EMAP 2005). Of course, acid rain was not the only environmental problem being addressed with interdisciplinary approaches but it was one of the most visible and one of the most expensive at a total cost of approximately $500 million (Winstanley et al. 1998). More importantly, it demonstrated that complex environmental problems required interdisciplinary approaches. It also served as a training arena for many young scientists that tackled the complex problems with innovative new approaches and interdisciplinary perspectives. Conscious efforts were made to integrate among disciplines such as biology, chemistry, meteorology, forestry, fisheries, statistics, geography, geology and others.

From an academic perspective, the highly successful Long Term Ecological Research Program (LTER) funded by the National Science Foundation began officially in 1981 (http://www.lternet.edu/). This effort was initiated and gained momentum at the same time as the National Acid Precipitation Assessment Program effort. The LTER program, while not focused on a specific societal problem, sought to combine scientific disciplines to understand complex systems and sought to develop a broad spatial understanding. The first Steering Committee Chair for LTER was Professor Dick Marzolf, a limnologist from Kansas State University, and principal investigator of the Konza Prairie LTER site. Interestingly, there is no lake in the Konza Prairie. The LTER program is a collaboration among more than 1,800 scientists and students investigating ecological processes over long temporal and broad spatial scales in 26 LTER sites. With the visibility and funding associated with the LTER program, many academic institutions housing involved scientists became aware that disciplinary lines of organization and management were breaking down as interdisciplinary collaboration flourished. Many of the students trained at LTER sites have since become involved in addressing environmental problems from within state and federal agencies as well

as universities. Their experience with interdisciplinary approaches is serving them and society well while working toward many complex environmental issues.

As we think about the absolute necessity of scientists to pursue broader collaborative approaches, it is important to mention the need for most scientists to be grounded in some specific scientific discipline. It would be a tragic mistake to focus on developing an entire cohort of generalist environmental scientists as many of the explicit tools we must continue to use are dependent upon disciplines such as systematics, taxonomy, biogeochemistry, geomorphology, ecology and, yes, limnology, just to provide a few examples. The point is, expertise in such disciplines is not sufficient, in isolation, to successfully address the more complex set of environmental problems we now face. Global change is the mega problem that societies are just beginning to address on an international basis. Changes in the major forcing variables of precipitation and temperature will affect ecosystems and their services across the globe and will form an important context for many if not all current and future societal-ecological problems.

3. Environmental Regime Shifts and the Need for Trans-disciplinary Approaches

The Millennium Ecosystem Assessment (MA) (Millenium Ecosystem Assessment 2005) catalyzed a broad focus on trans-disciplinary thinking that has generated or contributed to some very tangible evidence of action. Trans-disciplinary thinking is embodied in the concept of social-ecological networks. The trans-disciplinary approach expands the inter-disciplinary concept from having primarily different science disciplines cooperatively work together to now link these sciences with non-scientific disciplines such as sociology, economics, architecture and others. An outcome of this approach is the awareness in some circles of the need for societies to manage social-ecological networks and their feedbacks appropriately in order for these societies to persist (Diamond 2005; Carpenter et al. 2006). The challenges for science educators and their students of the future just became more broadly focused and steeper. The reality is that we must prepare students to understand and function within trans-disciplinary groups addressing the problems facing the current and future social-ecological networks.

Professor Steven Carpenter (a limnologist) has been one of the leaders in thinking about complex networks and the importance of recognizing regime shifts (Carpenter 2003). The MA considered the importance of regime shifts and their effects on human society. Regime shifts in ecosystems can cause rapid, substantial changes in ecosystem services and human well-being. Ecosystem services (e.g. water quantity, water quality, nitrogen regulation, carbon sequestration, etc.) are those ecosystem processes that are valued by human societies and which have typically been taken for granted (NRC 2005). Examples of some ecological regime shifts are (1) hypoxia of the waters of the Gulf of Mexico as a consequence of agricultural practices, particularly nitrogen fertilization, in the upper Mississippi River basin; (2) the 2008 reduction and closure of commercial salmon fisheries on the West Coast of the United States due to over-fishing, destruction of habitat

needed for reproduction and changes in ocean conditions; and (3) nitrogen fertilization phenomena expressed in the Chesapeake Bay where important fisheries have collapsed. Many other such situations are discussed in the MA. Unfortunately, examples of major regime shifts due to and adversely affecting human well-being are wide-spread and serious. An important point here is that in many of these situations where ecological regime shifts have occurred, the underlying causes are well studied and known but societies lack the will to remedy the situation. As these problems become more acute and wide-spread, affecting the actual survival of societies, the urgency to act will also grow more acute. It will not be solely up to scientists and academics to understand these serious problems but also it will be necessary for businesses, decision makers and voters to be able to grasp the important issues and their implications. Consequently, it is not sufficient for just scientists to develop these trans-disciplinary perspectives.

The foundation of environmental security is surely to provide for human health and well-being through the understanding and maintenance of those ecosystem services on which society depends. Provisioning services of food, fiber and water are essential as are those underlying services that regulate vital components in the biosphere such as nitrogen and carbon dioxide. Large scale regime shifts are clear evidence of large scale failures or even collapse in environmental security. This linkage is obvious and examples are widespread.

4. Educational Requirements for the Future

What then are the environmental educational needs for the future? First, I think that we need to think broadly about not only who will identify and project the future condition of ecosystem services based on societal actions but also who will elect decision makers and what background those decision makers will have in order to make good decisions? I think we need to consider three levels of curricula development: K through 12; university; and post graduate training.

The K through 12 curriculum needs to be focused on producing a citizenry that has the basic analytical skills and social-environmental background to understand, at some basic level, how totally dependent we as individuals and as societies are on ecosystems services. We cannot live without them. Moreover, our actions affect these ecosystem services at local, regional, continental and global scales. How we manage, conserve and restore these systems has direct consequences in many unsuspected ways: economically, socially, physically and emotionally. The well-worn perspective that "*all things are interconnected*" is the foundation of the needed education. Unfortunately, we now have multiple examples from around the world of how humans have mediated environmental collapse or regime shifts and the dire consequences for these environments and for the humans that depend on them. We have case studies! Perhaps more from the social science perspective, we need to have high school training turn out citizens that have skills in the area of critical thinking and evaluation. They will continue to be bombarded with media messages of all types and having the ability to identify and find truth among the messages cannot be understated.

At the university level, every graduate should be exposed to at least a year of a well-crafted, trans-disciplinary course of study grounded in environmental science, but broadly focused. These courses would be primarily for non-science majors and would be as important to their education as the currently required core subjects of language, composition and mathematics. As these university students become leaders in society they will need to be prepared to recognize and solve, collectively, problems associated with the society-ecological networks in which they live and cannot live without. This presents an opportunity for universities and their disparate departments to develop more trans-disciplinary courses focusing on humans in the biosphere and to bring in the study of successful and unsuccessful examples or case studies.

Graduate education in the sciences and other disciplines is already responding to some of the issues presented above, particularly in the small percentage of institutions involved with LTER programs. However, only a small number of science students will have an opportunity to work in this program or other programs emphasizing trans-disciplinary approaches to understanding societal-ecological networks and issues. Therefore, I propose that all science graduate students in all institutions should take at least one rigorous higher level course that deals with trans-disciplinary issues and approaches. Professional schools such as those training engineers, business executives, physicians and lawyers must also be included. These highly trained individuals often find themselves in positions to make important decisions that in turn influence ecosystem services and ultimately, human well-being. City councils, county commissioners, court justices and elected officials are in positions to make these important decisions on a daily basis. I would argue that it is currently possible to achieve a Masters in Business Administration or Doctor of Jurisprudence degree without ever taking a class focused on how the environment actually works and the details of how dependent humans are upon ecosystems and their services.

To end this discussion on a positive note, I point out the movement in the last 3–4 years of many universities in the United States toward developing a trans-disciplinary perspective regarding sustainability (Association for the Advancement of Sustainability in Higher Education: www.aashe.org). Some of these institutions have reorganized the standard departmental model into innovative combinations of skill mixes to foster trans-disciplinary perspectives, funding and research. Arizona State University (ASU) has established the USA's first School of Sustainability. By fall of 2008 the law school at ASU plans to introduce a law school minor in sustainability and a Joint Center on Urban Sustainability is planned with China. I view the concept of ecosystem services as a trans-disciplinary approach to organize thought and to evaluate options and progress toward achieving sustainability in societies. Many other major USA universities (University of Rochester, Berkeley, Yale, University of Pittsburgh, University of Chicago, University of Michigan, Stanford and others) are following this very positive recent trend in higher education.

5. Conclusion(s)

The concept of Ecosystem Services and the developing tools to understand them represent a core organizing framework for implementing trans-disciplinary approaches to achieve sustainability and human-well being that, together, lead to environmental security. Development and application of the Ecosystem Services approach is a means to identify needs and track progress in environmental security. Environmental education is the key to success in achieving environmental security. Table 1 summarizes the thoughts developed in this paper regarding what is needed in education to meet the new challenges of environmental security.

TABLE 1. Summary of educational needs to meet the challenges of environmental security.

Education level	Educational/ curriculum needs	Possible approach	Intended outcome
Kindergarten–12	1. Basic understanding of what ecosystems are, how they work, what they provide (i.e. Ecosystem Services) and how humans have made mistakes in managing them in the past 2. Basic understanding of the absolute dependency of human health and well-being on those services supplied by ecosystems	1. Combine the ideas embodied in physics, chemistry, biology and geography to introduce ecosystems. Take a "systems" approach. Define and discuss basic ecosystem services 2. Using case studies introduce and discuss the importance of human stewardship of ecosystems. Which decisions have been bad, which ones have been good	Students who complete primary and secondary education have a basic understanding of the total importance of ecosystems to humans. They understand how important it is to conserve, protect and restore ecosystem function. Students are critical thinkers and can make good (sustainable?) decisions when faced with difficult choices. They recognize false arguments and become informed voters
Undergraduate University	1. Improved (greater detail) understanding of	Approach depends on the undergraduate	Future leaders would be prepared to not only be critical

	what ecosystems are, how they work, what they provide (i.e. Ecosystem Services) and how humans have successfully and unsuccessfully managed them in the past 2. Improved (greater detail) understanding of the absolute dependency of human health and well-being on those services supplied by ecosystems	major but trans-disciplinary understanding is the goal. Cross school approaches combining sciences with social sciences is the basic idea. Systems approach would be emphasized and studied using broad approaches to real-world case studies. Trans-disciplinary teams would address term level projects	thinkers but to understand the importance of dealing with complex environmental issues from a systems perspective using trans-disciplinary perspectives
Graduate and Professional Education (lawyers, physicians, scientists, MBAs, etc.)	All students pursuing professional degrees would be required to take one survey course that provides a rigorous background in how ecosystems work, how they are essential to human survival and what state-of-the-art issues are being addressed to solve key environmental problems and the methods being used	In addition to lectures and readings, students would work in teams to prepare a solution based on trans-disciplinary understanding to an important and difficult local or regional environmental issue that threatens human health and well-being. Presentations would be discussed in class	These future decision makers would gain an objective perspective and critical thinking skills necessary to understand and to begin to address complex environmental problems and trade-offs. They will understand that there are unintended hidden consequences relating to almost every decision that affects ecosystem function and that success in making good, long-term decisions is vital to human well-being

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TRANSITION FROM STUDENT TO EMPLOYEE: THE NECESSARY SCIENCE AND SKILLS

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Abstract: University graduates leave school anticipating the rewards of employment in the academic world, with government agencies, non-governmental organizations, industry or consulting firms. They trust that they have the necessary knowledge and skills to be productive and successful employees. Both employers and prospective employees often are surprised when they discover the graduates are unprepared for the challenges of the workplace. This paper describes the combination of knowledge and skills that an employer would value in a prospective employee. Knowledge includes basic science, ecosystem interactions and policy. Skills include organizational abilities and creative problem-solving. The challenge to professors is to teach both knowledge and skills. While knowledge is important, skills are essential. Important skills include the effective use of web-based resources, creative methods for tackling problems, working effectively in a team as well as independently, effective communication skills, being able to answer questions in the face of uncertainty, and ethics.

Keywords: environmental science; skills; education

1. Introduction

University graduates leave school anticipating the rewards of employment in the academic world, with government agencies, non-governmental organizations, industry or consulting firms. They trust that they have the necessary knowledge and skills to be productive employees. However, both employers and prospective employees often are surprised when they discover the graduates are unprepared for the challenges of the workplace. It is not because the graduates come from unrecognized educational institutions or because they had poor grades (in fact, they often come from the most respected universities, and have won awards). Rather, it is because they were not taught the necessary combination of knowledge and skills needed to apply that knowledge.

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This paper describes the combination of knowledge and skills that an employer would value in a prospective employee. The highlighted knowledge and skills are equally important for graduates seeking employment in any sector including academia, government or non-governmental organizations, industry, or consulting.

2. The Science

There is a basic level of knowledge that students should obtain before graduating from university. Examples will be provided which are relevant to environmental sciences and addressing issues of environmental security.

The environment is a complex, interwoven, interacting series of biotic and abiotic systems. Chemical movement in the system also is complex (Figure 1) and may be influenced by several factors related to the biophysical characteristics of the system. This complexity requires that environmental scientists have an understanding of not only the individual components making up the systems, but how the components interact.

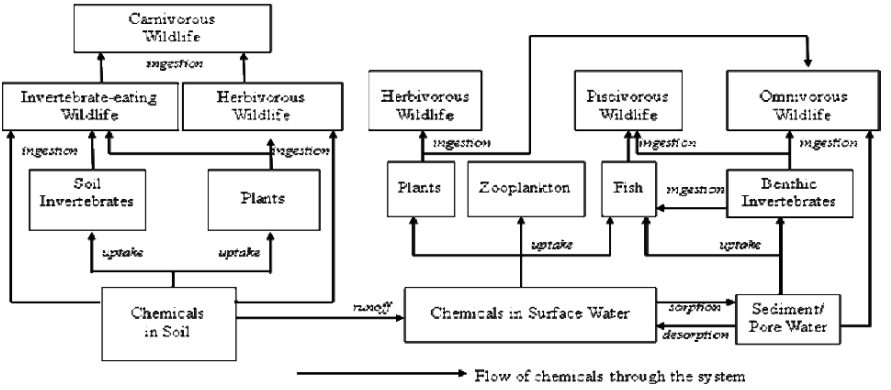

Figure 1. Conceptual model of chemical movement in the ecosystem.

Consider the reality of how the world operates. Contaminants are released from stacks, effluent pipes, leaking above-ground and below-ground storage tanks, etc. and enter the air, groundwater, surface water, sediment or soil. Understanding the basic chemistry of these compartments, and the contaminants within them, is important for identifying those compartments on which focus should be placed. For example, will the contaminant released to water stay in the water column or partition to sediment? The answer to this question will tell you whether focus should be on the uptake of dissolved contaminants from the water column into fish, or the uptake of contaminants in sediment to benthic organisms and then to fish via their diet. The interactions within and between compartments often results in complex answers to simple questions.

Ecology and food web interactions must be understood. For example, the contaminants in sediment may be a source of contaminants to fish that forage on benthic invertebrates (causing direct toxicity to fish), or result in an accumulation of chemicals in the fish, which may expose fish-eating wildlife or people to these contaminants. The contaminants also may cause direct toxicity to the benthic organisms, thereby removing or decreasing a source of food to fish, resulting in indirect effects on the fish (e.g. decreased growth, lower reproductive rates) due to less food or lower food quality. The implications of these linkages between environmental compartments are critical to understand in order to properly investigate the issue.

Ecological impacts go beyond contaminant impacts (Figure 2). Some of the most significant impacts on fish and wildlife are related to habitat loss or fragmentation (Lindenmayer and Fischer 2006). It is not sufficient to know that deer eat vegetation and that certain contaminants accumulate in vegetation (i.e. to understand the food web and contaminant flow through the food web). There must be an appreciation for the habitat needs of the species. For example, winter and summer habitats may be different, there often are specific requirements for den or nest sites for wildlife, food preferences may change during the breeding season, and species may require interior forest vs. edge habitat, which can be disrupted by urban development, linear developments (e.g. roads, transmission corridors), etc. Contaminant effects on components of the various habitats can result in different impacts on wildlife during different times of the year. In addition to chemical stressors, there are numerous possible non-chemical impacts on ecosystem components, such as urban development. Figure 2 illustrates several chemical and non-chemical stressors on a forest ecosystem around a smelter site, showing the effects of sulphur dioxide and metals, as well as logging, development, etc.

Science contributes to the development of government policies, but may not be the only influence on these policies. Students should have a general understanding of how policies are developed and applied. They should appreciate the differences between guidelines (i.e. recommendations) and standards (i.e. law). Policies also deal with uncertainty in the science in different ways, depending on the jurisdiction or the intended use or application of the science. For example, the science may be used more directly when developing a regional or site-specific guideline, than when used to develop a generic environmental standard (which may require the application of policy-derived uncertainty factors to the scientific data).

Students should graduate from university with a fundamental understanding of ecology, physiology, ecological interactions, chemistry, toxicology, and environmental policy. Interdisciplinary knowledge (e.g. economics, sociology) also is being recognized for its value related to environmental problem-solving (Landers 2009). This information must be *learned* as opposed to memorized. A student who can memorize and recite information, but does not understand it, will not be able to apply the knowledge or advance the science or application of the science; he will not be a valuable employee.

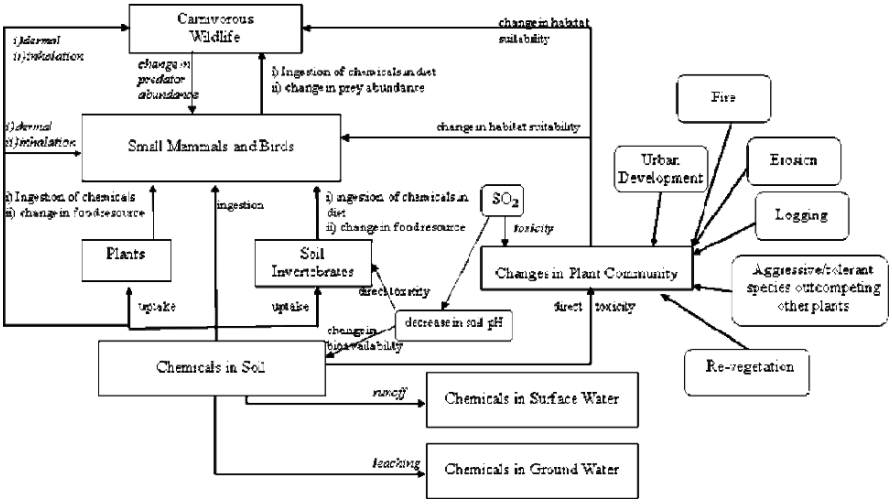

Figure 2. Conceptual model illustrating chemical and non-chemical influences on an ecosystem.

3. The Skills

Students take a large number of courses during their post-secondary education. They learn the basics of many disciplines and advanced theories and applications in their chosen field. This knowledge is important, but the skills they develop through this learning are essential. Without certain skills, students cannot effectively use the knowledge being taught to them. Advancing the science and applying the science in novel situations require a diversity of skills.

There is a misconception that these skills must be present in order for a student to successfully complete his studies. However, students are able to graduate without learning simple skills such as how to be organized, multi-tasking, true learning/understanding and creative problem-solving. This does not help the graduate when he enters the workforce.

Organizational skills result in efficiencies that are demanded in the work place. How many students work from 9 am until 5 pm and then relax with family and friends in the evenings and on weekends? A few disciplined graduate students, perhaps. Most students fill their days, nights and weekends with their studies, with breaks scattered throughout for sport, sleep and likely a trip to the pub or at least the fridge! The discipline of working a regular “business day”, and completing the necessary work within these specific hours, requires organizational skills.

Being organized means understanding deadlines, scheduling to meet deadlines, and how to efficiently complete the tasks to meet the deadlines. In the real world, deadlines often cannot be missed. Most assignments at school are completed independently. In the workplace, “assignments” may require input from only one person, but often they require input from many specialists working as a team, and

some tasks must be completed before other tasks can begin. Time management is essential (Ricketts 2001). There must be a commitment by all members of the team to a schedule to meet the deadline, especially when there are multiple tasks, including tasks that cannot be started until others are completed.

The workplace and school are similar in that there will usually be multiple projects or assignments that must be completed at the same time. *Efficient* multi-tasking is required. Many people multi-task in very inefficient ways! In fact, multitasking may seem more efficient on the surface, but may actually take more time in the end (Rubinstein et al. 2001). People must choose strategies that maximize their efficiency when multitasking, or avoid multi-tasking (Rubinstein et al. 2001).

Every job will inevitably come up against an unforeseen problem which may require creative problem-solving abilities. Standard methods are fine for addressing standard problems. New, complex problems may need to be addressed using creative methods that build on but go beyond standard methods. Creativity is as important for scientists as for artists! Some solutions may best be arrived at by asking an expert; other solutions may be best arrived at by working through the problem by oneself (Treffinger et al. 2000). Students need to learn how to work through complex problems in creative ways.

It can be assumed that graduates have a solid grounding in science. The key is to ensure these graduates also have acquired the skills needed to apply the science and be successful employees. Both knowledge and skills must be taught.

4. The Challenge for Educators

We do not place the entire burden of teaching knowledge, skills and ethics on professors! Learning is a life-long process, and current employees are eager to both share what they have learned, and learn something new from their colleagues. However, we do challenge professors to create an atmosphere of learning, with assignments and teaching methods that highlight the learning of skills, and stress the importance of maintaining scientific and personal integrity. Teach and test understanding rather than memory. This will take the institutional teaching of science into the real world.

In this electronic age, universities are teaching students the effective use of web-based resources such as for literature search and acquisition via the internet, identification of people to contact for information beyond what has been published, identification of government resources, etc. The issue is not one of a lack of information, but too much information being available on the Internet, and it is crucial to find the high-quality (e.g. peer-reviewed) information.

Students need to learn creative methods for tackling problems. Do not stifle creativity! Encourage them to take the time to think. When students understand the problem, they can think about possible approaches to the solution.

Deadlines are a reality of life. It is not a matter of simply losing 10% of your marks if you are late. You could lose an important contract or cause an experiment to fail! Meeting deadlines must be a priority, along with efficient multi-tasking, and working effectively in a team as well as independently.

Advanced knowledge and effective skills may lose their value if the knowledge cannot be communicated effectively. This involves both written and oral skills. Give students lots of opportunities to hone these skills.

One of the most difficult assignments for new graduates is to answer a question or problem in the face of uncertainty. Frequently, we may not have all the answers to a problem. However, decisions still have to be made; it may not be feasible to simply request more data! Students must learn that it is acceptable to arrive at conclusions and recommendations as long as the uncertainties are described and their influence assessed. There also must be a willingness to say "we don't know".

All the knowledge, understanding, and skills to use them are meaningless if the importance of scientific and personal integrity and ethics are not stressed and integrated into the learning process. Values and ethics are not innate; they must be taught (Ricketts 2001). Never allow clients, governments, or colleagues to influence the science or your interpretation of the science. Scientists have nothing except their knowledge, skills and integrity. Reputations built over years can be lost in an instant, if the perception is that a scientist will give the answer the client wants and not what the science indicates. A negative reputation remains with a person for a long time!

5. Conclusions

Graduates seek employment in academia, government or non-governmental organizations, industry and consulting. A solid combination of knowledge and skills will make these graduates valued employees. Knowledge includes:

- Basic science
- Ecological interactions
- Chemical impacts
- Non-chemical impacts and,
- Policy

While knowledge is important, skills are essential. These skills include:

- Organizational abilities/multi-tasking
- Creative problem-solving
- Effective use of web-based resources
- Working effectively in a team, as well as independently
- Effective communication
- Acknowledging uncertainty and,
- Ethics

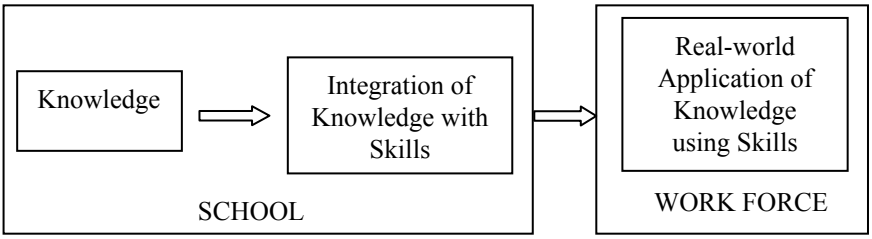

Figure 3. Integration of knowledge and skills is required.

Scientists in the real world are faced with addressing environmental challenges. What data and analyses are necessary to answer the question under investigation? How is the question influenced by policy? How do you obtain useful data? What are the implications of what the data are telling you? How do you integrate this information with other information you already have? The ability to integrate the science and skills will allow these questions to be answered.

The challenge to professors is to teach this combination of knowledge and skills. The process needs to start at school, to be used and strengthened in the workplace. It is only when the knowledge is integrated with the skills that the knowledge can be applied in real-world situations in the work-place (Figure 3).

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STAGES, PERSPECTIVES AND ALTERATIONS OF HIGH EDUCATION REFORM ON NORTH-WEST OF RUSSIA

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Abstract: Education system reform in terms of citizens' rights has become an urgent task in Russia's social, economic, and political development in the twenty-first century; the adaptation of the system to meet modern conditions of the European educational sphere is a very complex and multi-dimensional problem and its execution is a long-term process. The characteristics of previous reforms give rise to serious concern. The Bologna process will promote an effective search of new educational boundaries in Russia. As a member of the international community, Russia should consider the unification and integration of educational standards demonstrated by the European states. Since this kind of reform will demand cardinal revision of the fundamentals of educational policy and process in the Russian Federation, and therefore influence the rights and freedom of citizens, it is very important that our best traditions (fundamentality and universality of training) are not lost, and an adequate and comprehensible formula of Russia's participation in this process is found. This paper will illustrate that the use of pedagogical technologies is most effective in the case that involves participants of the educational process in real activity. "Researchers of the Baltic nature" is a modern program in the North-west of Russia, developed by The Baltic Fund for the Nature and teachers at Russian universities, to assist the ecological and biological education of youth through its design and project activity in the field of environmental protection. The three-level structure of this program involves field experience and youth engagement in the sphere of environmental protection, conservation of natural resources, and maintenance of sustainable development; students have the opportunity to become participants in Russian and international projects and grant programs, promoting the integration of the professionally-focused Russian youth into the international scientific community. Modern educational programs like this are successful with the participation of universities of the North-west of Russian and the European Union.

Keywords: education; ecology; sustainable development; competence approach

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1. Introduction

In connection with the reform of the education system proceeding in Russia, and also in view of gradual integration of our country into uniform European educational space, problems of realization of the constitutional guarantees of the right of citizens on education receive a special urgency. Increase of availability and efficiency of education is one of the major strategic resources of social, economic and political development of Russia in the twenty-first century. Mature democracy, public stability, high quality of economic growth in the country, its investment appeal and defensibility are inconceivable without the financing and developing of the public education system, which should take priority when compared with other spheres of life activity (Dobrenkova 2005b, 2006a). Modern education should promote formation of world outlook stability of the person and a society on the basis of humanism and tolerance, and as well as effective means of preventive maintenance of extremism (Lukin 2007).

Since the last decade of the twentieth century, the education system in the country has changed considerably. New principles have been proclaimed: a priority of the person's rights and freedom, democratization, humanization of education, its continuity and variability, respect and the account of regional and national features of training, and a wide autonomy of educational establishments (Dobrenkova 2006b, c).

2. Education Reform

Adaptation of the Russian education system to modern conditions is a very complex and many-sided problem, and its performance is a long-term process. However rates and character of reforms in progress cause serious concern. Reform of Russian education began in 2001 when "the concept of modernization of the Russian education for the period till 2010" was accepted. According to the specified concept, the basic purpose of education development in Russia is increase of its quality, availability and efficiency. Later, a number of the documents regarding further reformation of the education system were accepted. Today there is no unequivocal approach to a choice of conditions and forms of Russia's integration within uniform European educational space. So a wide and all-round discussion of conditions and rates will promote the effective search of new educational boundaries in Russia for the twenty-first century (Dobrenkova 2005a, b).

The processes of globalization affecting the educational sphere are shown by the aspiration of European states to unify and integrate educational standards, and the development of general criteria of educational policy within the Bologna process. Russia, as a member of the international community, should consider these tendencies. At the same time, similar reform will demand cardinal revision of fundamentals of educational policy and process in the Russian Federation. It is very important that, upon inclusion of the Russian education system in the all-European system of higher education, our best traditions (first of all, fundamentality and universality of training) are not lost and the adequate and comprehensible formula

of participation of Russia in the Bologna process is identified (Lukin 2007). Undoubtedly, the process of integration of Russia into the European educational space, assuming modification of educational legislation and standards, should render influences on the rights and freedom of citizens – participants of the educational process.

Absence of development of transition mechanisms to the European standards, insufficient legal maintenance of a two-level education system, for example, in the labour legislation, problems of employment and payment for "bachelors" and "masters" degrees do not allow citizens to realize their rights, and their opportunities are considerably limited (Dobrenkova 2006c). Therefore there is a necessity of urgent decision-making in order to solve these issues to not allow for infringements of the rights of citizens to get qualitative education and social security and to not undermine even further the trust of people to the chosen direction of a state policy on reforming Russian education.

3. New Approach in Education Process in North-West of Russia

Introducing Russia into global educational space is accompanied by essential changes in the pedagogical theory and practice of educational processes in leading universities of Russian north-west. Currently at the universities, there is a change of an educational paradigm, and new pedagogical technologies are being formed. For example, development and implementation of the concept of competence approach in Russian north-west reflects an orientation towards universal tendencies in education development that will prevent delaying Russia in educational process and maintain the high prestige of the Russian school.

The analysis of potential opportunities of secondary, additional and higher education in formation of key competences has shown that the pedagogical technologies directed towards the development of design ideas, skills to work in a group, development of functional literacy and social competence get increasing value. These factors should better enable success of personal, professional and career growth of youth. Use of similar pedagogical technologies is most effective in the case where there are opportunities for all participants of the educational process to participate in activities for conservation of natural resources at local level.

The problem of perfection of structure and the maintenance of natural-scientific education, namely, education in the field of an environment, wildlife management and biodiversity conservation, is actual for all levels of the Russian education system. It is necessary to change approaches to development as opposed to only education maintenance, as well as technologies of training. The Baltic Fund for the Nature, together with teachers of St. Petersburg State University and of some other universities, has developed and introduced in Russian north-west one of such modern programs titled "Researchers of Baltic nature" (Naturewatch Baltic). The main goal of the program is ecological and biological education of youth through their participation in design and project activity in the field of environmental protection. Operating conditions of the program allow coordinators to develop the activity, being guided by modern world educational practices such as interactive

education and competence approach. At the moment we can speak about the creation of the three-level structure of the program "Researchers of the Baltic nature" (Tarbaeva and Danilova 2007).

The first level "Involvement" provides inclusion in the program, where possible, for greater numbers of participants through group forms of work, such as outdoor activities, studying typical biotopes with the use of specially developed questionnaires, assemblies, creative competitions and projects. In this level pupils from 12 to 15 years old are involved. Every year about 80 schools, 120 teachers and 600–800 pupils come to our education program.

The second level "Motivation" gives pupils from 14 to 17 years old an opportunity to those interested by work in nature to carry out scientific research or to take part in the nature protection project, including annual conferences of young researchers, meetings with scientist-biologists, and an opportunity to become a participant of a children's research expedition or the youth project (about 300–400 pupils every year).

The third level "Opportunity and Chance" is reception by experienced youth in the sphere of environmental protection, conservation of natural resources and maintenance of sustainable development. Participants of the program "Researchers of Baltic nature" (youth of 16–21 years old) have a real opportunity to become participants of the Russian and international projects and grant programs. Thus the Baltic Fund for the Nature actively promotes integration of the professional-focused Russian youth into the international scientific community.

3.1 THE BASIC FORM OF WORK OF THE PROGRAM

(a) Trainings for teachers, including the development of modern pedagogical technologies for application towards nature education, are incorporated. Coordinators of the program give special attention to development of the educational technologies providing integration of design and research problems in educational processes, as well as training of teachers through pedagogical training, i.e. by activities that enhance essential education quality.

(b) Work with questionnaires, special guides that help to collect information about biotopes such as "Forests", "Rivers and Lakes", "Fields and Meadows", provides inclusion of youth groups in studying nature and preservation of natural resources. The major principle of work with the questionnaire is the analysis of a situation "*here and now*", that corresponds in higher education to "case study method" – participants independently estimate a specific situation, diagnose a problem and offer ideas and decisions in discussion with other participants. Filling out the questionnaire emerges from joint efforts of group participants and develops the interactive character focused on cooperation and partnership. We have developed the following questionnaires used on a regular basis by youth associations: «Research of gardens and park», «Research of agricultural landscapes», «Research of a

wood», «Research of the rivers and streams», «Research of coast of Gulf of Finland».

(c) Conferences, meetings and educational projects for pupils of St. Petersburg and Leningrad region will be organized for maintenance of a group of students with common interests to enhance skills of scientific dialogue, inclusion of youth in the scientific environment and formation of communicative competence. In a modern society, competence in the communication sphere became one of the main components of a high professsional level. Effective professional work can be conducted only in conditions of open and friendly partner contacts.

Educational travel for the organized groups of schoolboys is attractive to students and is a practical example of realization of ideas declared by the program and principles.

3.2 METHODICAL BASES OF WORK OF THE PROGRAM – COMPETENCE APPROACH

Competence is considered as the proved ability and readiness for action on the basis of the received knowledge, personal experience and the generated valuable installations.

3.2.1 Key competence

- It is necessary to learn action within the bounds of aims faced.
- It is necessary to be able **to submit actions with partners**, i.e. to have abilities of cooperation and making compromise.
- It is necessary to **know how to come uncurled**, i.e. to be able to engage in self-appraisal, action and reflection (quoted from the report text of the representative of the Council of Europe M. Stobart's 2002).

3.2.2 Professional competence

Working in the field of ecological and biological education for a long time and having a wide experience of close cooperation with nature protection organizations and authorities, we cannot ignore the fact that today, those who work in the field of wildlife management should not only love and be knowledgeable about nature, but also be skilled working with documents and have an operational experience with legislation in this area. Work with questionnaires is an original first step towards the formation of the competent expert in the field of Nature and Biodiversity Conservation.

3.2.3 Interactive training

Interactive training promotes personal growth, develops communicative skills, helps to establish emotional contacts between participants, and forms work-related skills in a group.

4. Conclusions

According to the concept of the competence approach we allocate three groups of results of participation in the program "Researchers of the Baltic nature".

1. *Personal results*
   - Forming of own position, opinion
   - Experience of presentation activity – representation of the position, opinion, results of the research
   - Forming of communicative culture
   - Ability of professional activity planning
   - Comprehension of received knowledge and skills (new opportunities in professional activities
2. *Subject field*
   - The generated representations about biodiversity of a region (species, ecosystems)
   - Acquaintance of a system of nature-protected areas and the basic strategies for preservation of natural resources in the world
   - Skill to recognize ecological problems (global and local) in region
3. *Experience of activity*
   - Skills in habitats mapping
   - Carrying out research in the nature
   - Preparing information and outreach materials – leaflets, booklets, posters
   - Garbage collection
   - Participation in development and implementation of games and other mass actions for children and youth

4.1 PROGRAM GRADUATES/OUTCOMES: THREE LEVELS

- *The first level* "Involvement" – people are not indifferent to problems of biodiversity conservation and usage of natural resources.
- *The second level* "Motivation" – specialists indirectly connected with environmental science.
- *The third level* "Opportunity and Chance" – professionals in environmental science – researchers, officials, specialists etc.

This program is only one of the positive examples of solutions to overcome new challenges in the field of education in biology and ecology. Since 2004 at the

Saint-Petersburg State University within the TEMPUS-program "ECODIV" (course development for new M.Sc. program "Sustainable Development and Environmental Management") some innovative educational programs with the newest technologies in the fields of biology, ecology and medicine are being successfully realized with participation of universities of Russian Northwest and the European Union. One of them is the innovative masters program "Biodiversity and nature protection", which was developed with support of the EU TEMPUS program and the Russian National Project "Innovative educational environment in the classical university". The main program objective is preparing well-qualified specialists, who can effectively deal with problems of saving biodiversity using a range of methods and approaches. In order to achieve this objective, the curriculum and the "rules" of the masters program are developed, such as criteria and regulations, based on European educational standards. These factors allow students to build up their own educational course using the potential of leading European universities (Finland, Sweden, France, the Netherlands). The Masters Program affords the possibilities for training scientific, social and professional competencies and prepares masters students to work in international environments in project management, concerning biodiversity protection on local, regional and global levels. An information package contains details about curriculum structure, students' schedule, training competencies and Masters Program rules.

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THE CONCEPT OF HIGHER ENVIRONMENTAL EDUCATION FOR UKRAINE

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Abstract: Environmental problems of Ukraine and its historical, geographical, technological and economical roots are presented. One of the effective ways to mitigate these problems is creating appropriate educational training to prepare the qualified experts to solve the practical environmental problems of society and economy, such as air and water pollution, soil degradation, reducing of biodiversity, etc. However, certain difficulties must first be overcome. For example, the main weaknesses of Ukrainian Environmental Engineering Education (E3) in Ukraine are low motivation of students for studying and low employability of graduates. An overview of the E3 program in Ukraine and its relationship to the requirements of the environmental sector of the Ukrainian labor market are presented. The following measures are adopted from European Universities and the Bologna principles, which strengthen the links between universities and society: public, industries, private business, and the exchange by students in frames of European Credit Transfer System (ECTS) and training teachers, commercialization and innovation university activities.

Keywords: Environmental Engineering Education; curriculum; employment

1. Introduction

Ukraine has quite difficult environmental problems that grow from the historical, geographical, technological and economical roots. Historically Ukraine occupied about 2% of the former USSR territory but accounted for more than 20% of former Soviet Union chemical, metallurgy, and military industries (National Report of Ukraine 2003). Geographically, Ukraine has minimal water resources compared with other former Soviet Union countries and most of its rivers are polluted via insufficient waste water purification in the majority of small towns and villages. The Chernobyl nuclear accident sharpened ecological situation and created many new environmental problems, such as nuclear contamination of large territory and related aspects of population health (National Report of Ukraine 2003).

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The transitional economy of Ukraine does not allow concentrating financial and technical resources to mitigate environmental situation in the required scale; only about 20% of Ukraine's financial needs are covered by state budget This current situation requires qualified experts that must be ready to solve the practical environmental problems of Ukraine, within the confines of the economic reality of the country.

Twenty years ago, graduates of classical universities were focused on the environment, but they could only address the question "What are we doing in the environment?" It was not enough because society and economy required answers to another question: "What can we do to minimize the human effects on the environment?" This answer could only be addressed by graduates of technical universities because it was primarily a question for engineers and economists. This was the beginning for Environmental Engineering Education in Ukraine. Environmental Engineers are now required for municipal tasks, management, most large industrial practices, environmental police, etc.

2. Improving Environmental Engineering Education in Ukraine

Kharkov National Academy of Municipal Economy was a pioneer of E3 education in our country. Similar to the developed concept of classical university graduates being ready to work as school teachers and researchers in the scientific institutes, technical university graduates must be ready to serve the needs of different areas of national economy as environmental engineers, and technicians (Figure 1).

There are two groups of environmental engineers that must be trained: regional environmental engineers and industrial environmental engineers. Regional engineers focus on problems of urban development agriculture and forestry. Industrial environmental engineers are focused on solving the practical environmental problems of different kind of industries, such as chemical, machinery, metallurgy, building, and transport.

Currently, environmental courses are included in the curriculum of nearly all specializations of Ukrainian universities to raise the environmental understanding for all graduates of higher education. This concept seems quite appropriate and it is working well, but our higher education system and its environmental segment has a set of difficulties. First, there is an insufficient educational level of incoming university students after completing secondary school – about 50% of students study fields that remain unrelated to Environmental Engineering. Second, and maybe the most acute difficulty, is the low motivation of students resulting in low employability of graduates. The absence of information about the graduates' first place of employment does not help students to focus their attention and spend their time and energy on the concrete courses related to Environmental Engineering: technology, modeling, legislation, etc. The Ukraine labor market is still adjusting to the newly independent statehood, which also creates many difficulties with employability of graduates. In general, the official unemployment in Ukraine is lower then the European average (6.4% in Ukraine versus 7.1% in Europe) (Ministry of Labor and Social Policy of Ukraine 2008), and the university graduates account to

approximately 1.5–2% of total unemployed persons officially registered with the state authorities. However, according to our own surveys carried out in the framework of EU sponsored projects, only about 50% or less university graduates work within their field of study and actually have the possibility to apply their knowledge and skills, hence extremely low motivation for academic achievements.

Further, the Ukrainian environmental legislation code is still being developed; in principle, it is being reformed to become in accordance with EU standards; however, it is not clear at the moment to what extent and in what direction acting legislative basis will be changed. Uncertainties and instability in governmental regulations towards the environment create additional problems with employability of environmental professionals (Kharkiv National Academy of Municipal Economy 2005).

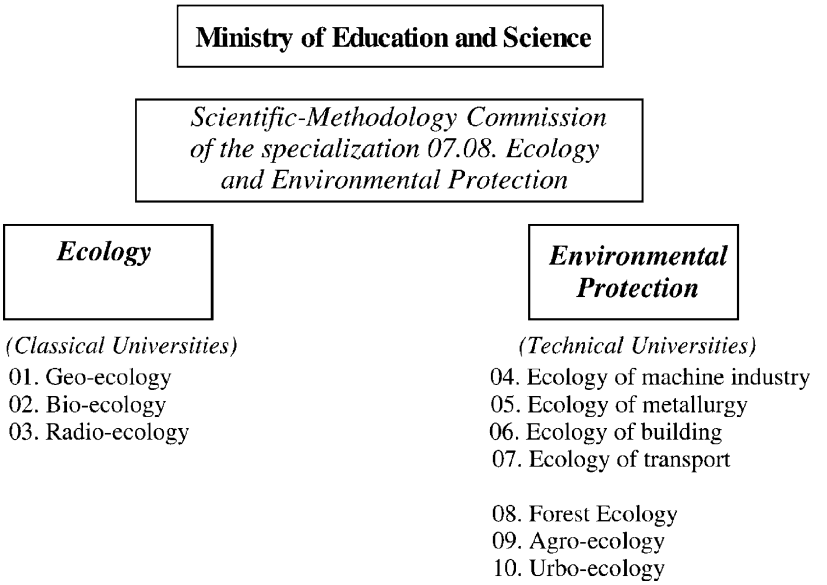

Figure 1. Scheme of environmental higher education in Ukraine.

2.1 COLLABORATION WITH EUROPEAN PARTNER UNIVERSITIES

There are two ways to improve the situation. The first is to harmonize the Ukrainian environmental curricula with those of other European universities by implementing the Bologna principles. The second is to strengthen the links between university and society, including public agencies, industries, and private business. Kharkov National Academy of Municipal Economy is adopting these strategies with valuable support of EU educational programs (such as TEMPUS-TACIS, ERASMUS-MUNDUS), the IREX program of USA, and the Small Grants program of British Council in Ukraine. TEMPUS-TACIS and ERASMUS-MUNDUS support the

development of the educational process. IREX and British Council grants are used for research of the connections between society and education.

The close cooperation with European universities in Finland (Vaasa University and Vaasa University of Applied Sciences), in Sweden (University of Kalmar) and in the UK (Abertay Dundee University) creates strong partnerships for this endeavor. First, we have done comparative analysis of curricular requirements for E3 of above mentioned universities and our academy. This analysis shows that our Academy requires more credits for Natural Sciences and Humanitarian Disciplines but significantly less credits for Informational Technologies (IT), Entrepreneurships, and Communicability (Figure 2). Results of this analysis were discussed with our Partner Universities, leading to the development of a harmonized school plan, or curriculum. The School Plan was approved by the Ministry of Education and Science of Ukraine on an experimental basis, and was implemented in the teaching process of Kharkov National Academy of Municipal Economy in 2006.

An intensive exchange program for students and teachers was arranged between our academy and its European Partners through ECTS to support this activity. A bilingual group for students was convened in our academy where instruction is provided in English.

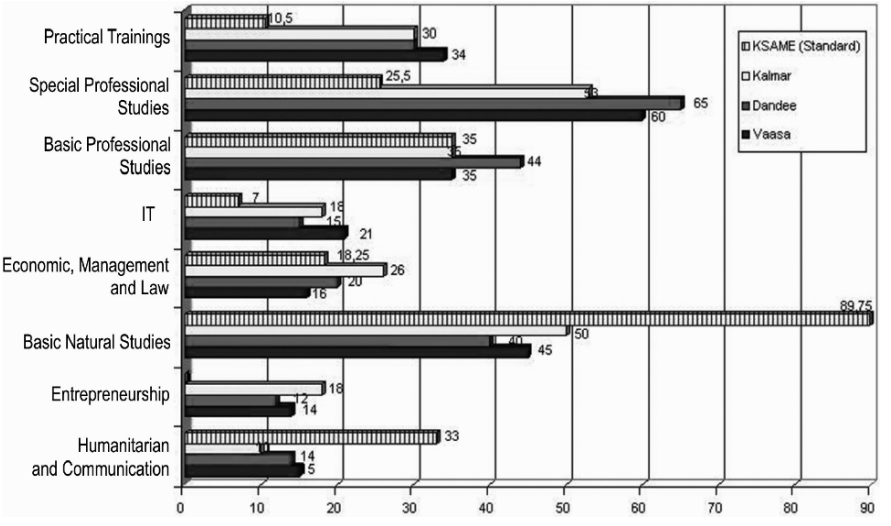

Figure 2. Inter-University comparison of curricula in environmental engineering. Blocks of subjects in ECTS credits (VAMK 2004–2006; Kalmar University; Ukrainian State Standard 2006).

To improve the employability of Academy graduates, the Career Service Centre, named "HELMET", was created through the TEMPUS-TACIS project, "Higher Education and Labor Market in the Environment". A data base of employment vacancies was arranged to which all students have free access.

Analyses of the environmental segment of the Ukrainian labor market shows that three employment tracks available for graduates: (1) managers for regional and central administrations, (2) engineers for institutions and companies to perform Environmental Impact Assessments for different projects, and (3) entrepreneurs for various environmental activities (Borysova et al. 2006).

To support entrepreneurship among our graduates and to help them to start with own business within the Academy, a special center was created through the TEMPUS-TACIS project, "Developing sustainable business patterns in Ukraine". Thus center, named "SUSBUS" is focused to support entrepreneurships of Academy alumnus in the environmental field. The main efforts of this center include the consultation of beginning entrepreneurs for sustainable business practice implementation in Ukraine.

To strengthen relations between academy and potential employers of graduates, we have tried to arrange a corporative system. Representatives of employers will have the opportunity to select third year students and to adapt their individualized school plans to meet their requirements for entry-level employees. This minimizes the time for graduates to secure employment and be valuable to the employer. This program ensures to close alignment between the academic curricula and the practical requirements of the labor market.

Lastly, another important initiative of our academy is the creation of the innovative incubator to join all existing Centers, such as HELMET and SUSBUS, to promote innovative activities, and to strengthen relations with industries such that the quality of education and employability of graduates are enhanced.

3. Conclusion

The analyses of environmental problems of Ukraine and possible ways to mitigate these problems through the modernization of the higher education system are presented. A description and discussion of these environmental problems should be included in the university curricula. This would allow for students to be prepared to solve such problems in their practical activity. The basic ideas of this paper and conclusions of discussions of other countries' experiences will be used to reform the environmental segment of higher education in Ukraine.

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PART III. NEW PRACTICES IN HIGHER EDUCATION IN ENVIRONMENTAL FIELDS

LEARNING BY DOING: THE UNIVERSITY AS A CURRICULAR TOOL FOR SUSTAINABILITY AND ENVIRONMENTAL SECURITY

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Abstract: Sustainability, the movement to ensure intergenerational equity of environmental, economic and cultural resources and institutions, is inextricably tied to environmental security through a shared concern for the future and for value based education. In institutions of higher education, enacting collaborative endeavors between institutional agendas/priorities and student learning is integral to both the educational mission and broader sustainability goals. When students learn by doing and are empowered by their contribution to a shared long-term vision, the impacts on academic and personal development are both enhanced. As faculty, we are able to align our learning objectives with direct application, and move our universities towards more sustainable practice. Likewise, our institutions benefit from concrete, tangible information to improve their operations. Successful examples of collaborative efforts between students, academic units, and facilities and operations at Ithaca College (USA) and other universities include curricular enhancement through projects related to topics such as energy, food systems, waste reduction and landscaping. Additionally, the collaboration of environmental studies students with marketing, business, historical, social, and communication programs has resulted in increased overall project quality and student involvement in sustainability issues. These efforts also benefit the institution by encouraging shared knowledge, student citizenship and global perspectives while strengthening the overall curriculum and fostering systems thinking.

Keywords: sustainability; education; experiential learning; institutional collaboration; student collaboration; shared knowledge

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1. Introduction: Environmental Security, Sustainability and Universities

Sustainability is intricately linked to environmental security. As defined in the United Nations Millennium Project (1998), environmental security is "the state of human-environment dynamics that includes restoration of the environment damaged by military actions, and amelioration of resource scarcities, environmental degradation, and biological threats that could lead to social disorder and conflict". Without achieving a state of environmental security, it becomes impossible to imagine sustainability, with which "the needs of the present are met without compromising the ability of future generations to meet their own needs" (National Research Council 1999).

One of the greatest hurdles to implementing effective environmental policy and achieving lasting environmental security has been in the failure of educational systems, especially in eastern Europe and the republics of the former Soviet Union, to train students with adequate transdisciplinary systems thinking skills to tackle the complex transboundary environmental problems that confront us today (Allen-Gil and Borysova 2007). As the mandate becomes clearer for colleges and universities to both teach future generations the knowledge and tools they require to address complex problems, and to emulate the concepts and ideals of sustainable and therefore collaborative development, academics and institutions are developing new approaches to do so. One successful approach is to more fully integrate academics and operations by using the university as a curricular tool.

2. Sustainability and Environmental Security

Sustainability is commonly defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" as presented by the Brundtland Commission (National Research Council 1999). In order to work within the sustainability paradigm, individuals, universities, and societies strive to balance environmental, equity, health and economic factors such that the integrity of all three is simultaneously maintained. Thus, the transition toward sustainability requires a concomitant emphasis on environmental security; for without ensuring adequate access to quality resources that are not degraded by pollution, sustainability cannot be attained.

The mandate for scientists to work diligently to ensure environmental security and sustainability has clearly been put forth by the American Association for the Advancement of Science (Lubchenco 1998; Raven 2002). Likewise, the urgent role of colleges and universities to educate on issues of environmental security and sustainability and adopt sustainable teaching goals has been clearly expressed by Orr (1992), Cortese (2003), and the American Association for Sustainability in Higher Education (AASHE) (2005). With the need clearly stated, how can this best be accomplished by both professor and institution?

Both environmental security and sustainability are multi-faceted concepts that require a multi-, or better yet, inter-disciplinary approach. Addressing issues of environmental security requires integration of scientific, political, ethical, and

economic considerations. For example, reducing threatened security caused by depletion of firewood resources requires scientific knowledge about tree adaptation and growth, political enforcement of laws to prevent overcutting, ethical valuation of the role of trees in ecosystems, and economic assessment of the costs and benefits associated with reforestation plans. Often, individuals with various expertise can be brought together to collectively work through a solution in a multi-disciplinary approach, yet this approach is little practiced in the academic curriculum. Only individuals trained and practiced in learning with *and* working with more than one discipline bring a truly transdisciplinary perspective to the problem solving process. Students and citizens who participate in this caliber of education can use the resources of various constituents to achieve a multifaceted perspective and solve complex global problems.

Consider the Darfur region of Sudan in its threats to environmental security. While the underlying cause of the conflict is the overexploitation of limited resources, it has been exacerbated by the social tensions between two ethnic groups to the extent that political and military forces now dominate the conflict. Starvation, migration, and alienation prevail. Understanding the problem will require knowledge of local political systems, historical economic development, and regional effects of environmental depletion. Solving it will require ecological restoration, sustainable economic development, social conflict resolution, and political mediation, each collaboratively with professionals of different backgrounds. Clearly a multidisciplinary approach involving science, sociology, politics, and economics is essential to solving issues in Darfur, as is the full engagement of problem-solvers with the seriousness and moral gravity attached to these local issues in the context of their global perspective. Finally, the importance of hands-on education, which ties tangible local contexts to global systemic issues, cannot be ignored, as students who actively participate in their academic projects will go on to pursue issues of environmental security with true moral investment.

3. Sustainability and Higher Education

In the face of these and other cases of imminent environmental instability, it is vital that students who are poised to become problem-solving, policy making, or peer-educating citizens are able to adopt a systems-thinking approach. In this ideal mindset, sustainability is understood and valued, their own strengths and areas of knowledge can be balanced with others', and security issues are understood in their full complexity. Emphasis on the interconnectedness of these student needs throughout any institution of higher education allows for unique bridges between issues of institutional need and development with coursework learning objectives. This approach benefits the institution while fulfilling societies' need to prepare tomorrow's citizens for resolution of environmental conflict and security issues. Copernicus, the University Charter for Sustainable Development (1993), clearly states the need for this type of sustainable-values education: "Education at all levels, especially university education for the training of decision-makers and teachers, should be oriented towards sustainable development and foster environmentally

aware attitudes, skills and behavior patterns, as well as a sense of ethical responsibility. … This requires a new frame of mind and new sets of values". In its development of ten principles for global university action, this Charter promotes efforts which encourage transdisciplinary educational opportunities related to sustainable development.

The Copernicus Charter and other university declarations such as the American College and University Presidents Climate Commitment (ACUPCC) and Talloires Declaration (Association of University Leaders for a Sustainable Future 1998) define the role of higher education as key to establishing environmental values aligned with sustainable development by calling upon persons across disciplines to learn and collaborate with one another (Creech 2007). The core values of sustainability education are inherent to larger goals of higher education, making collaborative efforts aligned with and increasingly viable opportunities for original academic endeavors and institutional excellence.

For instance, higher education is part of an on-going process of informing and mobilizing citizens to understand the consequences of their actions and relevant social, environmental, political, and historical effects. Understanding and practicing sustainability requires recognition of the diversity and interrelatedness of natural systems, global conflict emergence, and connections between biological reality and philosophical possibility. Clearly, universities are primed to use issues of environmental degradation as a basis for analytical application across disciplines, and prepare strategies for global response and prevention. Additionally, in both regular higher education and throughout sustainability education, both student and professor are driven by the curiosity for knowledge and determination to practically and morally implement their learning. Additionally, "The integration of the academic sector with sustainable campus initiatives is essential", writes Jenks-Jay of Middlebury College (2004). The physical needs of the institution often mimic those of local and global environmental security issues making exploration of even highly accessible university resources beneficial to students' understanding of more complex topics.

These intersections create learning opportunities from institutional goals and physical needs, allowing problems or areas of improvement and disconnect on the campus to become tools and applicable experiences. They can also expand the audience for sustainable education to related non-academic stakeholders within this community. Partnerships across departments, facilities, and stakeholders can become truly transdisciplinary with benefit to themselves and their entire academic community, becoming genuinely indicative of a long term values-shift. In doing so, the definition of academic success expands to include the creation and promotion of learning opportunities ripe for the emergence of values, rather than the production of specific ends, which remains important to institutional learning (Tainter 2003). Institutions which create learning situations that both develop and practice reflexive sustainable values increase their institutional worth, expand their departments' abilities, and incite civic engagement from students. The university can and has been used as a tool to create these situations in coursework, transdisciplinary endeavors, operations management, and extracurricular involvement.

Cortese (2003) expresses the necessity of preparing students to become collaborative citizens and the critical role institutions play in allowing students to develop an active appreciation for the interconnectedness of environmental concerns; "The envisioned framework for higher education will result in the transdisciplinary, systemic learning and practice needed to provide the educational experience for graduates to lead society on a sustainable path". By practicing collaboration through collaborative and institution-wide projects, the university becomes a vehicle and representation of environmental values-based problem-solving. Students learn under a unique model, "of citizenship and citizenship education developed on the principles of ecology and ecological interdependence" (MacPherson 2005). Institutional sustainable education impresses the need for students to act with integrity when confronting environmental crises, and their willingness to enact necessary change, by placing the power to shape real, dynamic systems in within their reach. This approach moves beyond using institutions as the vessel for information transferable, and into their utilization as resourceful learning opportunities.

4. Ithaca College Case Examples: Opportunities Within the University

The college campus functions like a small metropolis, with opportunities for facilities improvement and planning living in coexistence with the well-being and learning of its members. Like a City Development Plan, a Comprehensive Environmental Plan allows for a visionary guide on how to manage these interlocking systems for the benefit of all. The Comprehensive Environmental Plan (2001) at Ithaca College stemmed from a student capstone project, and continues to provide institutional guidance today. Other projects in energy, waste, resource management, and food-systems operation have afforded unique opportunities for both departments and students, while increasing the function of the city-institution and its community members' investment in the values of sustainable progress.

4.1 ENERGY

The campus has inputs of energy and resources which it processes and transforms on site, which must then be properly disposed. This system is no different than a city or national energy system, making it the perfect loop for energy-security learning. For Ithaca College, energy and electricity currently comprise approximately 5% of the operating budget (Ithaca College 2008), and thus the college is eager to embrace energy conservation measures if the proper research is conducted to ensure benefits outweigh costs. Student research projects have been used to provide this information. For example, one student was bothered that the lights were left on in the library all night. His research demonstrated a potential savings which led the college to turn off 1/3 of the lights after hours (Ross 2004). An independent study on Ithaca's heating, ventilating, and cooling (HVAC) system revealed use of the 100 fume hoods in the science building to be a major contributor to the building's energy consumption. Between 20–33% of the fume hoods

were left on unnecessarily at any time, resulting in unnecessary expenditures of $70,000 a year and the release of harmful pollutants and greenhouse gases (Rajan and Clark 2005).

Similarly, a pair of students found that energy could be saved by replacing old refrigerators with newer, more efficient models; their report stated that replacing the 23 1992 refrigerators would save $628 and eliminate 6 t of CO_2 emissions per year (Krasnow et al. 2005). Another study revealed that if all 150 computers in the science building were power managed (screens turn off after 20 min of inactivity; CPUs enter sleep mode after 1 h of inactivity) the school would save $4,036 and prevent 24 fewer tons of CO_2 released annually; this is the same amount of energy used to light 27 average US homes (Rivard 2006). Students in the 2005 *Projects in Sustainability* class, worked with representatives from the local sustainable living community, EcoVillage, to offer an information session on campus about their design for installation of a solar-powered fountain in the campus's Chapel Pond. Most recently a group of students investigated the energy and cost savings associated with lowering the thermostat in one of the dorms by 1°F. They found that the college could save over $35,000 annually (Handerhan et al. 2008).

4.2 RESOURCE AND WASTE MANAGEMENT

Resource consumption and waste disposal facilities are zones within a university metropolis that allow for both analysis and redesign as opportunities for environmental education. The flow of resources into the institution, and removal of waste, allows for learning in areas such as influx reduction, consumption analysis, waste management, and repurposing of materials, which each mimic systems of social-environmental concern. Especially creative uses can be found for the study or reconstitution of resource and waste systems, and utilization of remaining by-products, and reducing resource costs allows capital to be freed from recurring costs such as disposable supplies, waste facilities maintenance and trash disposal fees, providing momentum for closed-loop or zero waste campus policies.

By integrating input from the Ithaca College waste collection manager, one Ithaca College student developed a 6 week media campaign aimed at increasing to recycling rates in on-campus housing. The campaign was incorporated with a national American initiative called the "RecycleMania" competition as its technique mirrored the larger competition and provided additional initiatives for students to participate. This internship provided an opportunity for the student to combine educational campaign skills, analysis of the flow rate and type of the college's waste stream, and cost reduction benefits while additionally supporting the institution's commitment to the American College and University Presidents Climate Commitment (ACUPCC). The project was part of a larger effort, which fulfilled a component of one possible greenhouse gas reduction action: "participate in the Waste Minimization component of the national RecycleMania competition, and adopt three or more associated measures to reduce waste" (ACUPCC 2007). The student intern and other campus residents increased their appreciation for the finite

state of natural and manufactured resources, a key concept to environmental security.

The First-Year Seminar course at Ithaca College *Sustaining Our Worlds: Hope for the Future* requires students to identify solutions for waste management and other facilities on campus. Given categories such as "electronic waste", (e.g. batteries, cell phones, computers), "recycling bins", "paper usage", "recurring cost reduction", (e.g. renewed departmental supplies, such as paper and copying materials), and "composting", students identify and create a plan for improving an area they feel can be improved in 1 year's time. The seminar participants in 2006 surveyed students via online messaging on their willingness to pay for greener bookstore clothing and class materials. The study showed students were willing to pay an average of 5% more than the cost of regular supplies for 'greener' and 'local' materials (Kaiser et al. 2006). Another group of students in 2005 analyzed paper usage in ten humanities departments on campus, and found that 100% recycled-paper policies could cut recurring supplies costs by 6% without any harmful effects on machinery (Brylinsky and Volpichelli 2005). They presented briefs of their findings to department chairs, and seven of ten departments changed their policies to save money and reduce overall product consumption. In order to effectively share their findings with stakeholders on campus, students learned from chemistry, business, and public communications professors in their First-Year Seminar. By practicing the mediation of public education with environmental knowledge, students gained the ability to create successful policy campaigns while simultaneously saving the institution waste resource costs. Their projects required active collaboration with peers and departments, and resulted in a tangibly beneficial outcome students themselves could take pride in. The benefit to departments was noticeable enough for a 30% recycled-paper purchasing policy to become standardized institution-wide by 2005 (Brylinsky and Volpichelli 2005).

4.3 FOOD SYSTEMS

Areas for sustainable education can also utilize both existing food systems or create alternatives as a means of generating or saving revenue and increasing the local environmental and human health of the university. A group of environmental studies students worked with dining services in 2004 to find more sustainable packaging and food purchasing options. From supporting local "no-till farming" to reducing plate and packaging waste, students found that dining halls' issues were related to larger food security issues related to transportation and growth practices. The students created an action plan for the incorporation of organic foods. They cited the benefits of soil carbon sequestration and energy deintensification, provided a chemical agricultural analysis, and highlighted the transportation savings if the facility moved towards biodegradable packaging products. Another group of students from a communications course then complemented the analysis of food, energy, and packaging sources by compiling geographical, nutritional, and packaging inventories in a professional marketing portfolio. The collective final report included suggestions for the incorporation of local food sources and

biodegradable packaging and disposable service-ware purchasing (Banet and Brylinsky 2005).

Issues of food security and transportation stability were an integral part of this project. One student noted that apples, a local food source in the college's region, were being shipped over 2,500 miles from the state of Washington rather than being purchased from numerous local vendors. Another student discovered that the cost of packaging-waste removal, from items such as plastic silverware and sandwich containers, could be replaced with biodegradable products at 0% profit decrease if composting services could accommodate the 15% resource increase. The report also found that total food purchasing had increased by 160 lbs per year, while food waste had increased by 240 lbs, and it was figured that increased use of biodegradable packaging could lower waste costs by 16%. Total calculations revealed that the campus could re-direct 28% of its non-disposable waste stream into compost facilities at a savings of nearly $300,000 annually after a 2-year payback period. This report was used by the college's Physical Plant staff to increase composting in 2007; dining services moved to purchasing all biodegradable service-ware the same year.

Collaboration between students and dining services resulted in noticeable benefits for the department, resulting in the department adopting the mission and slogan of "*Sustainable, Healthy, Fresh*". Additionally, dining services opened a local foods station, which serves lunch and dinner options prepared from all local and organic food sources. These changes have allowed for healthier dining options for students and faculty, while decreasing institutional dependence on future-unstable transportation services and environmentally degrading production farms. In 2007, the food services department was selected to present at the North Atlantic Regional Society for College and University Planning (SCUP) conference on the success of their sustainable food focus, providing even greater opportunities for shared knowledge resulting from student projects on campus.

4.4 TRANSDISCIPLINARY APPROACHES TO IMPROVING ENVIRONMENTAL PROGRAMS

Numerous disciplines can provide essential information for better environmental management decisions on campus. Cross-disciplinary learning strengthens the student perspective of global connections and creates a complex learning space similar to the complex nature of our surrounding ecologies. Curricular areas that are especially relevant include business management, social history, web development, strategic marketing and organization, systems thinking, business and mathematics. These areas compliment the environmental studies curriculum by adding communication and outreach tools to the students' foundational knowledge, enabling their ability to share the significance of environmental security and sustainable living issues with others.

Communication students receiving degrees in marketing, organizational management, instructional design, and corporate communications are required to complete an environmental marketing and consumer-education project as first-year students.

The "Introduction to Strategic Communication" course, open to and attended by students of all majors for its practical skill application, culminates with students exploring avenues on campus where students could launch and be receptive to advertising, communications, web-media, or program-management campaigns which might increase commitment to environmental learning, or lessen the institutional footprint. For instance, students created a business plan and marketing campaign for an undergraduate-geared website which would connect students across disciplines to exchange knowledge for sustainability related projects in their courses.

In mathematics, assistant professor Tom Pfaff incorporates environmental issues into his coursework for calculus students by using excel-based curve fitting techniques to explore contemporary environmental issues such as oil-supply and consumption, its impact on global warming, and mathematical approaches to solving energy-based issues. In the process, students are equipped to solve contemporary issues in both the local and global context. Environmental studies students benefit from practical application of their broader knowledge, and mathematics students benefit from a contextual placement of abstract theory which highlights the relevance of energy issues. In the business management course "Sustainable Micro-Enterprises", assistant professor of management David Saiia teaches students the principles of microenterprise development, "bottom of the pyramid economics", master branding, and communicable business application through environmental, Ecuadorian case studies. Students are able to continue learning by putting ideas for solving local sustainable-enterprise issues in the Choco-Andes corridor into practice by traveling to a cloud-rainforest conservation organization, Fundacion Maquipucuna, where they participate in a summer program exploring land quality and community agriculture issues solved first-hand. Saiia recruits students from across disciplines to participate in the course to ensure problems posed throughout the semester are discussed from a truly transdisciplinary approach.

Environmental studies students are invaluable to these classes, but these students also benefit from the expertise of peers and the opportunity to mediate social, economic, and communication needs with ecology needs. Sharing curricular activities between departments has resulted in heightened student involvement and mutual departmental growth at Ithaca College. Other universities have experienced similar benefits: "This shared learning process helped each of us to dispense with our simple, and sometimes wholly false, assumptions about the broader reality that had evolved within our isolated disciplinary communities" says Norgaard of the Massachusetts Institute of Technology (2004).

Expanding learning across disciplinary lines strengthens the institutional values of collaboration, rather than competition, which in turn fosters a sense of common purpose (to mutually achieve a sustainable future) in faculty, staff, and students. Furthermore, departmental sharing of tacit knowledge is as important as openness with explicit knowledge. When the academic setting is positioned such that information flows freely between constituents, resource costs and time is saved,

and students develop in a culture that fosters a core understanding of the interconnectedness between human interests, resource consumption, and collaborative responsibility for the state of their environment.

4.5 BEYOND ACADEMIC BOUNDARIES FOR CURRICULAR ENGAGEMENT

Using the institution as a curricular tool is also effective for creating opportunities for outreach and involvement in the campus and community. To return to the metaphor of the institution as a city, often city boundaries are unclear, and the surrounding lands and people exchange both commerce and public interests with the node of urban activity. Academic departments as the hub of the institution share space with a multitude of staff, non-departmental students, and visiting agents. Similarly, the entire institution shares living space, resources, and human interaction with surrounding towns and businesses and can both use and give back to these resources in mutually beneficial exchange. "Experiential learning offers an educational experience that most effectively: connects the academic with the practice, fosters an effective transdisciplinary curriculum, links students to work experience and job opportunities, and engages and empowers students" (Domask 2007). Exchanges between the campus and the larger community inevitably benefit the institution through a willingness to exchange land space, town or city resources, and volunteer work as a result of positive experiences with collegiate students.

4.5.1 Campus and professional collaboration

The entire campus community can often be engaged by a single event or project on sustainability. A combination of Physics and Environmental Studies students developed a bike docking station in which one could park a bike and ride for exercise, while at the same time producing energy for installment in the campus fitness center (Oberg et al. 2008). Projects such as these can then be used as demonstration projects for the rest of campus. The bike, and a solar photovoltaic system mounted on a trailer (also built by students as a research project), were used as the sole sources of energy for a "smoothie stand" for Earth Week in 2008, where staff, faculty, and students could enjoy a free fruit drink while learning about alternative energy sources on the campus common green. Students are also currently playing an important role in gathering the information to assist the college in fulfilling the commitment of the President's Climate Commitment by collecting data to construct a greenhouse gas inventory, conducting a feasibility study for wind energy on campus, and developing alternative transportation plans.

Annual projects or events become ongoing spaces for educational involvement. Every year Ithaca College hosts the Finger Lakes Environmental Film Festival (FLEFF) which screens over 100 environmentally-related films at various local venues over a 2-week period. Films are screened as a part of over 25 courses on campus, and focus on topics ranging from war ethics to marketing theory as part

of the festival's commitment to expanding the definition and dialogue around 'the environment'. Environmental studies students, as well as students in other disciplines, serve as interns for FLEFF to obtain the greatest degree of hands-on experience. In 2008, 75 student interns carried out various tasks such as creating viral marketing using non-paper or low waste ad-campaigns to attract local attendees and facilitating post-screening discussion about the intersections of various environmental themes. The Cinema and Photography professor, who co-hosts the festival with a Politics professor, states that "Environments need to be reframed as systems comprising incessant interactions, changes, fluidities, movements, transversals. Environments may exist, but they can also be produced. Environments are only sustainable if they are heterogeneous, multiple, complex..." (Zimmerman and Shevory 2008). Their commitment to non-traditional and transdisciplinary themes each year allow students and faculty to broaden the dialogue around issues of environmental security simply by participating as viewers at the festival. In 2007, a "Memes" theme prompted student projects about the viability of destructive resource management and compromised social change, and in 2008, "Gastronomica" inspired many projects exploring the growing divide in food-allocation and resource consumption globally.

4.5.2 Community

While the campus itself provides excellent applied training opportunities for environmental and sustainability studies, the opportunity to integrate students with the larger community is also vitally important (Allen-Gil et al. 2005). In Michael Smith's Environmental History course, students annually complete local environmental history projects in collaboration with the local History Center in downtown Ithaca. Since 2006, projects have included an assessment of the environmental degradation and subsequent need for brownfield remediation from decades of dumping lead into the gorge adjacent to a world-famous small-arms manufacturer (Evasick et al. 2006), trajectory progressions of Native American trails into modern roadways and the consequences on riparian habitats due to increased impervious surface retention (Brylinsky and Caligiuri 2007), and an analysis of the effect newspaper media's perceptions of atomic energy in the mid-1960s, the private scientific concerns, and the local community's actions against a nuclear energy site planned for nearby Lansing (Baker and Jennings 2007).

These projects enrich community awareness of environmental issues and allow students to review past human failures to adequately plan for land use and community security in efforts to advance technological and transportation progress. Another student in an Environmental Toxicology class examined the deterioration of rusty metal in local area soils for zinc and iron traces in an effort to study the effects of unsafe dumping practices. She traced the source of the detritus to several truckloads of trash and leftover construction material dumped in the woods in the mid-1960s; citing the toxic effects of high levels of iron and zinc on plant and animal life, the student offered recommendations for remediation and cleanup of this old dump site (Spitz 2007).

Practical experience through internships with local non-profits organizations and business has also greatly benefited Ithaca College students. According to Alblas and Wals (1997), "Internships…promote salient qualifications of complex environmental problem solving which are relevant for the development of research capabilities in environmental sciences". Students are encouraged and often required to obtain community work experience in the form of an internship, either paid or non-paid employment, for the purpose of furthering and practicing current academic learning. In 2007, two environmental studies students completed internships for Ithaca's Tompkins County Department of Planning. The pair completed a riparian stream buffer ordinance, stormwater protection zoning laws, and developed a plan for conservation overlay zoning for the county (Brylinsky and Gwinn 2007) by completing the same number of work hours as a regular academic course. Other interns have created inventories of local green businesses for a community non-profit, developed bio-diesel stations for a start-up business, and worked with local resource disposal companies to perform educational outreach programs in primary and secondary schools. Experiences in the community strengthen ties between the town and institution making grants and successful collaborations more likely, and allow students to gain valuable work experience to increase hiring capacity.

Students can be engaged in a sense of local civic duty in addition to work responsibility through their ability to combine coursework and academic credit with activist organizations. Energy Independent Caroline (EIC), a group committed to helping the town of Caroline, NY become 100% independently wind powered, worked with Ithaca College students to educate Caroline townspeople on the benefits of participating in an energy movement. Issues of fuel dependence and rural transportation within the context of energy security were a key component of the campaign, which allowed students to find innovative approaches to persuading and educating non-environmental locals of the value independent energy sources have to local economic security. Students have also learned through the independent eco-living center in Ithaca, EcoVillage at Ithaca. Elan Shapiro, EcoVillage at Ithaca educator, taught "Projects in Sustainability" at Ithaca College in 2006 and allowed students to research and create a root cellar for 15,000 lbs of produce to sustain winter community meals at the living center. Shapiro's students also worked with an alternative transportation group called 'Connect Ithaca' to research personal transportation systems which could localize pedestrian traffic in the city center. Academic areas of inquiry, such as the effects of urban design on energy consumption, were explored. The projects encourage active application of environmental education in the local community and provided examples of how even those still learning from institutions of higher education can use their academic and skill-based knowledge to create a more sustainable community.

4.6 EMPOWERING THE INDIVIDUAL

Encouraging students to move beyond the boundaries of traditional curricular studies can be difficult, especially when little institutional support or precedence exists. Yet it is these experiences that prove to be most rewarding for students, and

place them on the path to becoming capable environmental leaders. Community and transdisciplinary experiences, combined with relevant course application, allow students to explore areas of self-motivation related to contemporary issues facing their local and global communities. At the same time, this learning approach fosters greater civic responsibility and understanding of ecological interdependence. Empowered students benefit professors, departments, and the institution. They create their own paths for learning which often coincide with institutional needs for sustainable development.

Extracurricular student organizations at Ithaca College have taken charge of student-to-student educational programs and have heightened awareness and investment for issues of energy independence, resource consumption, personal contributions to global climate change, food nutrition and availability, and other environmental security matters within the campus community. Students can apply to live in the Sustainably Conscious Living Community (SCLC), an alternative living community focused on self-education and environmental service. As the program is directed by students' educational desires, and guided by volunteer faculty expertise, students benefit from the ability to selectively fill gaps in their environmental education, from living in proximity to like-minded peers from outside of their academic concentration, and from a sense of identity as an environmental leader on the campus. Examples of SCLC projects include the 2005 dormitory residents introducing vermiculture composting to the building and self-mandating the use of local foods in community meals at which the sharing ideas and concerns in the community takes place. The SCLC has become increasingly popular on campus, with enrollment having risen from 16 applicants in 2005 to over 100 applicants in 2007 (Positive Growth Report 2007). Faculty volunteers have cited the SCLC as an ideal platform for experimental environmental education and insight into emerging interests and gaps in student education.

Another program, ICARE, provides a more informal and ongoing opportunity for student involvement. The ICARE program began in 2006 when a group of students from various student, environmental, and representative organizations on campus created a forum for student-body exchange in order to create priorities for the student sustainability agenda. Representatives from the student government, student environmental society, and resource and environmental management interns (REMP interns), began collaborating with students interested in economic equality, women's rights, and political justice organizations during free time outside of the classroom. This self-regulated forum created an approval system for campus events, wherein any department, student, or faculty member may present their on-campus activity to the ICARE committee for review, and receive the ICARE logo for use on advertising if the activity meets the groups' requirements for resource consciousness, global perspective, and local environmental consciousness. The success of this internal branding has been attributed to the democratic nature of the ICARE committee and willingness of the campus community to adhere to a self-guided review process.

Opportunities such as these which allow students to create their own learning communities inevitably benefit the institutional community. In 2006, a group of students raised funds to travel abroad to study ecotourism opportunities by

encouraging campus members to donate a small monetary contribution in exchange for their commitment to use alternative transportation for 1 month. A group of recreational studies students organized a bike-sharing program in 2004, and environmental studies students created an online car-sharing application for their assignment to "explore the 'reduce' component of responsible resource management in the Ithaca College community". Students participating in these projects were able to gain practical skills and resume suitable accomplishments creating a future investment which bolstered public awareness of student preparedness for pupils attending Ithaca College. Other students have created online calendars of sustainability events, hosted teach-ins or discussion forums on select environmental security topics, and organized peer participation in the national student conference on global climate change, PowerShift 2007.

5. Conclusion: Enhanced Education, Institutional Benefits, and Environmental Security

We have demonstrated the realm of possibilities that exist for using the university operations as a training ground for environmental studies and science and sustainability studies. As a microcosm of society, universities offer opportunities for energy analysis, food systems and production, resource use and disposal, and systems thinking approaches. Using the university as a learning platform is a win-win situation: students gain real-world, decision-making experience, while the university benefits from the generation of innovative ideas and approaches, as well as data collection and analysis that allows improvement in operations.

A hidden benefit of this approach is that environmental education becomes grounded and reflective of the values of the institution as a whole. Teamwork, responsibility, and reliance all become integral elements of the educational experience for undergraduate students. Unlike most in-class group projects, students using the university as a curricular tool interact with university employees, and this interaction further expands their cumulative and marketable skills and experiences. Likewise, the university becomes a greater reflection of the values of environmental stewardship and sustainability. There are countless examples at Ithaca College and other universities of this type of cross-fertilization in terms of energy conservation, reduction of food waste, landscaping, purchasing, and land management.

Environmental and sustainability education should also be fully integrated with the local community. Stepping outside the university setting gives students critical real-world experience with corporations, non-profit organizations, and local governments. In addition to the benefits of these types of projects on campus, students experience a variety of work environments, making them highly employable in the labor market. Students should be trained using a transdisciplinary systems thinking approach, combined with real-world projects that produce demonstrable results for the institution or the community. By doing so, the students leave the university more educated about the multiple facets of sustainability and environmental security and better prepared to further these universal goals in their own careers.

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A STUDENT'S PERSPECTIVE: THE BENEFITS OF NON-TRADITIONAL METHODS OF ENVIRONMENTAL EDUCATION ON ENVIRONMENTAL POLICY

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Abstract: Non-traditional methods of environmental education allow us to better understand the natural environment in which we are living, learning, and working. In order to make the most beneficial and comprehensive environmental policy decisions, this "personal" knowledge, and therefore non-traditional approaches within environmental education, is crucial. While considering student responses to these methods, this paper will suggest definitions for traditional and non-traditional methods of environmental education, highlight examples of non-traditional methods from institutions of higher education, and embark on an exploration of the importance of these methods on fully understanding the unique setting in which the institution exists and making the most effective environmental policy decisions for the area. Concluding questions concern the successes of a general approach to environmental education versus a focused approach at the post-secondary level.

Keywords: non-traditional education; sustainability; policy; environment

1. Introduction

Over the last few years, the term 'sustainable' has been used in a continually broadening multitude of contexts: as a requirement for policy and new technology, as a way of life, and as an emerging necessity for survival. Sustainability is defined as "the ability of the earth's systems, including human cultural systems and economies, to survive and adapt to changing environmental conditions indefinitely", and a sustainable society is one that meets current and future resource needs of its people without compromising the ability of future generations to do the same, as outlined in the 1987 Brundtland Report (Miller 2007). Practicing sustainability is a

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new, overarching goal that requires a shift in our current ideologies. Has the global community as a whole implemented sustainable policy, created sustainable technology, or begun the transition toward sustainable lifestyles? While these questions are subject to a debate and the answers differ based on region, it is clear that the broad community is aware of many of the complex changes required to transition to a more sustainable global society. Achieving a full understanding and appreciation of all earth's interrelated systems is vital to formulating the most beneficial regional policy decisions. This will require a shift in our education systems away from traditional methods of environmental education and towards non-traditional methods.

In Rachel Carson's *The Sense of Wonder* (1965), she writes "It's not half so important to know as to feel". We distinguish traditional education as that which promotes the "know" alone in its methods of instruction, whereas non-traditional education is considered to be that which encourages the "feel" as well as the "know". This revised approach to environmental education is becoming increasingly important in developing solutions to environmental issues. One fundamental shift in education practice toward non-traditional methods is that these methods place the student *within* the environment, rather than regarding the student as a separate entity. Through non-traditional methods, the student is personally affected by the condition of the environment and is more aware of the vast interconnections of all of the earth's systems, thus the need for broader policy change is reinforced. By moving beyond book-based learning to place-based learning, non-traditional methods of environmental education allow us to better understand the natural environment in which we are living, learning, and working. This "personal" knowledge and the non-traditional educational approaches required to nurture it are crucial for making the most beneficial and comprehensive environmental policy decisions.

During the European and North American Enlightenment through the eighteenth and nineteenth centuries, coinciding with industrial revolutions, the mission of the modern university was established: to "render [nature] subservient to human purposes" (Orr 1996). This mission shifted the aim of education away from any grander purpose and to focus it into specialized disciplines in order to further industrialize the earth (Orr 1996). The modern university is shaped by this mechanistic, utilitarian model based on Cartesian dualism (separation, objectification) and the Baconian method (manipulation and control, quantitative measurement). As this educational worldview shaped the scientific and industrial revolutions, it has molded society's functioning (Clugston and Calder 1999). Traditionally, "most learning takes place within well-defined disciplinary boundaries" within which we study individual components of a larger system (Bardaglio 2007). To achieve a truly 'sustainable' society, a paradigm shift towards a systems thinking approach must now occur, thus breaking the cycle of specialization, industrialization, control, and destruction. In higher education, we can begin to implement a systems thinking approach through non-traditional methods of environmental education, including active, hands-on, experiential learning, rather than the traditional, passive, specialized, lecture-based learning.

The Center for Ecoliteracy (CEL) in Berkeley, CA, USA promotes hands-on activities, such as stream restoration projects and neighborhood environmental justice work, which partner students with natural systems for mutual benefit (Stone and Barlow 2005). The concept of a "slow" school or education, one that focuses on process rather than outcome and emphasizes philosophy rather than memorization, is discussed by Maurice Holt in *Ecological Literacy*, a compilation of work conducted by partners of the CEL (Holt 2005; Stone and Barlow 2005). Holt draws an analogy between the current education and the fast food industry, defining the slow food movement is a "battle against a way of life based solely on speed and convenience" (2005). Aspects of a slow or non-traditional education include: (1) a variety of teaching approaches and methods, (2) working with the community both socially and politically, (3) bridging disciplines and linking themes within those specializations, and (4) engaging the teacher and learner on the solutions to complex problems such that students influence their own learning (Holt 2005). The slow school model emphasizes full understanding rather than compliance – perhaps this is the approach we need to inspire change in policy rather than allowing a continuation of the current system (Holt 2005).

Education is a key factor in whether we are able to make sustainable policy choices (Wackernagel and Rees 1996). Thus, as educators, we are responsible for making this shift toward non-traditional methods of environmental education that will foster environmental security and sustainability. The challenges of sustainability and need for policy change require changes in behavior, and this behavior change should be emphasized within the education system, implementing opportunities to take action both on and off the campus (Rowe 2007). Behavior regarding environmental issues can be altered through a curriculum that not only teaches skills of issue analysis and investigation, but also one that provides time for the application of these skills, thus developing a thorough understanding of system dynamics (Coyle 2005). To understand the full benefits of sustainability, we need to go beyond the traditional methods of teaching theory to the practical methods of showing and demonstrating sustainability in action (Filho 2002). The Sustainability Revolution, as described by Andres Edwards (2006) in *The Sustainability Revolution: Portrait of a Paradigm Shift*, is comprised of worldwide initiatives to move toward a more sustainable lifestyle, including moving business practices toward "mimic[ing] natural systems". How can we make the decisions necessary for the success of the Sustainability Revolution, requiring a full understanding of the complex nature of a sustainable system and making use of this understanding in terms of policy change, without personal experience? How can we have this personal experience without a shift toward non-traditional methods within environmental education? Rather than universities acting as contributors to the specialized, mechanistic social structure with its traditional methods, universities have the potential and capacity to produce holistic system thinkers that will allow us to collectively shape a truly sustainable society.

2. Place-Based Education: Understanding the Immediate Landscape

2.1 WHY DO WE NEED TO UNDERSTAND THE IMMEDIATE LANDSCAPE?

The characteristics of the societies of our global environment (such as physical conditions, histories, stages of development or industrialization, access to resources, environmental regulations, and social systems) are wide in scope and of particular significance in countries undergoing rapid transition (Klavins 2002). Environmental differences contribute to "different societal outcomes of success or failure" (Diamond 2005). Thus, environmental education and policy methods in one region may not necessarily be applicable to another. The engagement of students within their immediate environment through non-traditional methods will promote the most beneficial policy decisions for the local area.

The modern, industrialized world separates people from their environment. Current homogenized development (such as shopping malls, freeways, neon-lighted strips) discourages people's sense of connectivity and responsibility to the planet and its invaluable ecosystem services (Orr 2005). Thus, for educators influenced by and operating in this setting, the idea of 'place' is nebulous; no longer is it the immediate place a source of food, water, energy, materials, and recreation (Orr 2005). Even the construction of modern educational buildings demonstrates little sense of place, ecological awareness, or "relation to any larger pedagogical intent" (Orr 1996). Education becomes a separate entity from the whole societal system. Since academic institutions are the origin of many modernizations and technological advances in the developed world, it seems that higher education, the very source of industrialization, is where change needs to happen (Monastersky 2006). Developed societies have the resources required to make changes in the academic institution, in terms of, but not limited to, curriculum reform and technological advances (Salmi 2006). Developing societies, on the other hand, may not necessarily have access to the human and technological resources needed to gain the knowledge of how to make the most environmentally beneficial choices, provide solutions to environmental degradation, and implement these changes (Katikiti 1999). In fact, the environmental problems themselves are often hindrances to progress as the need for immediate solutions to short-term crises take priority over long-term, distant concerns (Klavins 2002).

2.2 REGIONAL DIFFERENCES IN ENVIRONMENTAL PROBLEMS AND PERSPECTIVES

Societies in transition, shifting from one political system to another and/or reorganizing production, are often burdened with serious human health and environmental problems, demonstrating the tight connection between socio-political and environmental issues (Klavins 2002). Countries in earlier stages of development face challenges of environmental degradation as a result of agricultural practices (slash and burn techniques and cattle grazing), air pollution (fuel and

coal burning stoves), and water pollution (runoff, domestic waste). More industrialized nations must combat industrial waste, air pollution from power plants and an increased reliance on motor vehicles. Advanced industrialized countries have the ability to invest in green technology, promote ecological awareness of citizens, and strengthen the government capacity to implement environmental protection efforts (Park and Tschang 1999). How can the approaches of industrialized modern societies be applied to areas facing different challenges? It is difficult to successfully implement certain practices when there is such a "sharp disparity between the resources that are available for higher education and the educational standards they are supposed to maintain" (Park and Tschang 1999).

For example, events of the transitional period to statehood in Latvia have altered the environment and living conditions, making the impacts of this transition visible through increased cases of infant mortalities and cancer (Klavins 2002). These changes point to the importance of environmental education, which is imperative for a better understanding among the public and policy makers about the ramifications of environmental problems on human survival. This example also highlights the importance of restructuring the education system to meet the social, economic, and environmental needs of society. The rapid changes in many facets of Latvian society necessitate an understanding of integrated science, encompassing a breadth of academic disciplines, which can be achieved through non-traditional methods of environmental education, mechanisms to "know how a particular problem might be resolved" and benefit society based on unique needs (Klavins 2002; Park and Tschang 1999).

2.3 HOW DO NON-TRADITIONAL METHODS OF ENVIRONMENTAL EDUCATION PROVIDE AN UNDERSTANDING OF THE IMMEDIATE LANDSCAPE?

According to educational researcher Edgar Dale, "people remember only 10% of what they read, 20% of what they have discussed, and 90% of what they have experienced" (Stone and Barlow 2005). Thus, non-traditional methods of environmental education, including hands-on projects, field work, and community involvement, leave a more lasting impression on students than the traditional, abstract, theoretical lecture-based education. A personal experience allows for the most comprehensive understanding of the unique local environment and therefore results in the greatest environmental and educational benefit for the region as the classroom issues are directly applied to the local environment. Because students see how they are connected with and affected by the local environment, improved regional policy decisions, which consider the effects of change on all components of the system, are made.

At the heart of the non-traditional approach to education are four major questions, outlined by environmental educator Mitchell Thomashow, which should be addressed to ensure environmental improvements and an understanding of interrelationships of earth's systems (Miller 2007):

1. Where do things that I consume come from?
2. What do I know about the place where I live?
3. How am I connected to the earth and other living things?
4. What is my purpose and responsibility as a human being?

These questions are addressed at the En'owkin Centre in Penticton in British Columbia, a post-secondary institution that implements indigenous knowledge, systems, and practical skills within the academic curriculum in order to demonstrate "principles of collaboration, sharing, and sustainable land use" (Armstrong 2005). At this institution, education is a natural part of the community, rather than the modern, segregated system (Armstrong 2005). The concept of ecological design involves a new liberal arts curriculum, one in which students learn to combine human goals with the flows of the natural world and implements the four questions presented above (Orr 1996). Hands-on projects within the natural environment allow students to experience the ecosystem services that are crucial to our survival, but are too often taken for granted, including role of earthworms in soil regeneration, soil bacteria that fix nutrients, bees as pollinators, birds that spread seeds of wild fruit, and plants that decompose wastes and recycle nutrients (Diamond 2005). The Field Biology course at Ithaca College (USA) immerses students in the local environment, in which they learn to identify local flora and fauna, to use current methods for developing population estimates, and to observe natural and cultural patterns in the landscape. Courses at Oberlin College (USA) involve students in campus issues that bridge to larger societal issues; for example, a study of food systems beginning at campus dining halls demands that students research agricultural patterns and food systems on a larger scale (Orr 1996). The implementation of non-traditional methods of education is equivalent to an "education that builds on solving real problems" – the key to effective regional policy change (Orr 1996). By experiencing a personal connection with the environment, rather than understanding their lives as separate entities, students find that environmental issues are of major concern and understand their role as individuals in these problems and, thus, this approach inspires active learning and community involvement (Collett 1996). Connections are made between course content and the students' lives as global citizens, and hopeless societal issues become manageable (Collett 1996; Orr 1996). Students are active in their own education (Coyle 2005).

These non-traditional approaches can be contrasted with the traditional, outdated idea that "learning occurs exclusively in classrooms, laboratories, and libraries" (Orr 1996). Currently, institutions of higher education use standards, such as test scores, tuition, and percentage of faculty with doctorates and publications, and endowments, to communicate the quality of education (Orr 1996). An education system that recognizes its place within a complex web of earth's systems would use different factors to determine its ability to educate, including material consumption rate, carbon dioxide emissions per student, waste management policies, community restoration projects, student preparedness to spur transition to a sustainable society, use of investment power to build sustainable economies, and what graduates do in the world (Orr 1996). Students of traditional institutions feel

the pressure to meet competitive standards as quickly as possible, absorb and demonstrate knowledge with incredible precision; with this kind of focus, little time remains for self-realization and broad understanding of societal connections (Holt 2005). The traditional education model creates student products of industry rather than free-thinkers that challenge current policy; in the U.S., the education system is seen as "too passive and non-participatory" by most evaluators (Coyle 2005). Through the separation of theory from practice, students' test scores may be high, but in-depth understanding of the interconnection of the earth's systems is low – the crucial component to making the changes necessary for our survival.

With the traditional education model, students are encouraged to retain many facts provided through books and presentations. Too often, students are disengaged from and frustrated by their studies, and this information is forgotten after the course comes to an end. Students may begin to question the lasting value of their education. Am I getting the education, the appropriate knowledge and skills, to precipitate change and improve the quality of life? Are my tuition dollars driving an industry that produces seemingly learned students as quickly as possible and instilling the ideals of quantity rather than quality? The non-traditional approach allows for a lasting educational impact on students – students are directly engaged, and their experiences allow them to recognize their connection with the landscape, begin to desegregate themselves, and realize the importance of their education on understanding the unique challenges of working toward sustainability in the immediate landscape and causing long-term, positive change.

3. Implementing Non-traditional Methods Within Higher Education – Case Studies

Perhaps the best way to educate students is to integrate sustainability into a variety of subjects (Bardaglio 2007). The interdisciplinary approach is demonstrated by various institutions of higher education around the world.

3.1 ITHACA COLLEGE, USA

Ithaca College, NY, USA (6,000 undergraduates and 350 graduate students) has an environmental studies program that encompasses both environmental science and environmental studies majors and minors, hopes to soon support a sustainability minor, and incorporates sustainability themes in all academic disciplines across campus (Allen-Gil et al. 2005). As the "first true collaboration between a college and a sustainable community", Ithaca College's partnership with the local eco-village, EcoVillage at Ithaca, provides project-based courses where a local community serves as a "valuable living laboratory", using scientific analysis to assess a sustainable community and address real-world problems (Allen-Gil et al. 2005; Bardaglio 2007). Noteworthy courses include:

1. *Sustainable Energy Systems*: students create a plan for more sustainable energy use in the county.
2. *Environmental Futures*: students engage in campus and community dialogue on environmental issues.
3. *Environmental Science*: students take weekly field trips within the city of Ithaca to better understand stream restoration, the lake's ecosystem, and waste water treatment.
4. *General Ecology*: the students' understanding of the interconnection of the earth's systems and the negative ramifications of human's attempt to isolate and control these systems is fostered.
5. *Sustainable Land Use*: a field based course that focuses on land use planning process in the context of the region and involves work at the local ecovillage (Allen-Gil et al. 2005).

Other courses outside the Environmental Studies Program also serve to enhance student learning through community engagement and integrated, applied experience. The *Proposals, Grants, and Reports* course at Ithaca College offers the opportunity for students to actively engage with initiatives of off-campus organizations, such as the Green Resource Hub, a public education, training, and green development center in Ithaca, to write professional proposals for project funding. As with most non-traditional coursework, completing these grants leaves students feeling that their effort had a larger purpose beyond simply making progress toward a degree (Stumpf 2008). At Ithaca College, students have the opportunity to develop and complete individual research, work-study, or independent-study projects with professors, providing an opportunity for students to pursue personal interests beyond course material.

Having recently completed the construction of the new School of Business, targeted for U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) platinum certification, and in the process of building two additional LEED certified buildings, Ithaca College is molding the academic building to match the college-wide practice of sustainability. Reinforcing sustainability ideals through the physical classroom will serve as a constant reminder of the interconnection of education and environment, uniting theory and practice. College clubs and organizations, such as the Ithaca College Environmental Society and Students for Sustainability, engage students in sustainability initiatives both at the campus and community levels. These non-traditional, hands-on, active learning environmental education initiatives at Ithaca College strengthen community ties, foster an appreciation for the interconnectedness of the earth's systems, and develop students' personal relationships with working environments through direct engagement with the immediate landscape (Allen-Gil et al. 2005).

3.2 HAMBURG TECHNICAL UNIVERSITY, GERMANY

At the Hamburg Technical University in Germany there is a focus to spread sustainability "across university life and beyond" involving a bridge from student life to social issues of employment and well-being (Filho 2002). The Hamburg

Experience at the University was established to give participants the skills to pursue sustainable development and make connections for employment opportunities with local companies and authorities putting students' knowledge into practice (Filho 2002). Staff is working to establish a "Sustainability Centre" in the city of Hamburg to promote related work such as sustainable purchasing and agriculture and fair trade (Filho 2002).

3.3 UNIVERSITY OF AEGEAN, GREECE

Courses in the Department of Environmental Studies at the University of Aegean in Greece allow students of different backgrounds to collaborate to outline solutions to problems, fostering improved future communication (Skanavis 2002). The University supports an undergraduate and graduate student-run, non-profit, environmental education organization to promote public awareness of environmental issues through campaigns, primary and secondary school outreach, and internship opportunities with environmental companies (Skanavis 2002).

3.4 ASIA AND PACIFIC

Environmental education in the Asia-Pacific region includes regional sustainability networks, including the Southeast Asian Policy Advisory Network in Global Change, though "interactive electronic medium" to share environment-related data, and The Nautilus Institute for Security and Sustainable Development, based in San Francisco, CA, USA, works in cooperation with institutions in the Asia-Pacific region to increase awareness of regional environment issues (Park and Tschang 1999). The U.N. Environment Programme-sponsored Network for Environmental Training at Tertiary-Level in Asia and the Pacific works to enhance environmental expertise of educators, students, and policy makers through electronic workshops, research programs, and waste and zone management projects (Park and Tschang 1999). Through these programs, students can directly see the significance of their university education in the community.

These place-based perspectives motivate students to pursue engagement at the community level, as non-traditional methods direct students toward a "scholarship of engagement", thus breaking the 'college bubble' that separates students from their landscape (Allen-Gil et al. 2005; Josephs 2008). Courses that encourage a revisiting of childhood connection with nature, through projects such as writing environmental autobiographies, reawaken a strong care and attachment to a place as a 'home' and motivates activism to counter local environmental threats such as forest clearing (Corcoran 1999). It is this engagement with the immediate landscape that is needed to promote the most beneficial policy decisions for the region. Creators of environmental policy need to fully know the place to which the policy applies. Although distant policy makers have good intentions, the thorough understanding of a place that can only occur through personal experience and feeling the impact of the policy they have created is absent, thus the optimum policy decisions cannot be made (Josephs 2008). The traditional methods of

environmental education foster a 'think rather than do' approach that lacks the foundation of hands-on, living experience (Josephs 2008).

4. Why Do Non-traditional Methods of Environmental Education Improve Environmental Policy and Security?

The headline of a recent issue of *The Ithacan*, Ithaca College's weekly student-produced newspaper, read "Disengaged from democracy: Ithaca College's political scene is tame after years of protest and activism" (McQuade 2008). The article contrasts the intensity of campus protests of the 1970s with the apparent disengagement of today's students from politics, despite the college's liberal reputation (McQuade 2008). Although small pockets of political activism exist, the general student body is "not politically active at all", according to Marty Brownstein, associate professor of politics (McQuade 2008). Although Brownstein does not believe that the college was any more politicized in the 1970s than it is today, he does understand Ithaca College to be devoted to "careerism and self-development, which may not be political" (McQuade 2008). In fact, New York Times columnist Thomas L. Friedman has characterized today's youth as "less […] politically engaged than they need to be" (McQuade 2008). Although students believe that college is a place to learn and become active members of society, political reform initiatives remain few and far between (McQuade 2008). Despite the environmental education initiatives at Ithaca College, it seems that a more college-wide, comprehensive, in-depth shift in approach to non-traditional methods of education is needed as an antidote to the political disengagement and a way to promote more effective political decision making. Perhaps a study on a correlation between students of non-traditional education methods, such as the students in aforementioned Ithaca College courses, and greater political involvement of these students compared with students of traditional education methods would reveal a positive, direct correlation and more evidence to support the use of non-traditional methods for promoting change.

The Rochester Institute of Technology in NY, USA offers an interdisciplinary Ph.D. program in sustainability, joining engineering, science, economics, and public policy, in which students learn the importance of simultaneously considering the technical, social, economic, industrial, and environmental impacts of design (Fogg 2006). For example, while working on a waste handling project, students account for the expense of transporting the waste, the environmental impact of disposing the waste, as well as the social consequences of this process (Fogg 2006). The interdisciplinary character of non-traditional methods of environmental education will reduce specialization and prepare students to become active decision makers and identify priorities – one student response to this program format was that it "makes you a better manager and better business person because you know a lot about everything" (Klavins 2002; Fogg 2006).

In a Radical Environmentalism course at the University of Vermont, USA, students are involved in "action research", going "beyond the library" to speak with companies' policy makers (Kaza 1999). Through these extramural interactions,

students learn, first-hand, the motives behind company policy and experience the circumstances that may direct policy decisions (Kaza 1999). Through non-traditional approaches to environmental education, encompassing projects that focus on current sustainability issues, students learn to be "more environmentally, economically, and socially responsible and how to support policies and legislations that support a sustainable future"; students understand that they can, and how they can, have a positive impact on the planet (Rowe 2007).

The importance of education in the policy decision making process is evident in the significance of "community-wide understanding of the […] process and criteria to be used in selecting among [the] options" (Wackernagel and Rees 1996). In short, the policy development process involves the recognition and identification of the problem, the identification of specific causes of the problem and development of a solution (passing of a law), the implementation of the solution, the control, monitoring and adjustment of the solution (Miller 2007). The ramifications of policies can be best understood at the local level because community members experience the effects, and thus the most beneficial policy decisions are made beginning at this level.

Currently, less than 10% of the U.S. public considers the state of the environment as one of the nation's most pressing concerns despite the threats posed by population growth, wasteful resource use, and poor environmental accounting (Miller 2007). Thus, to make environmental issues more relevant to citizens, education addressing these issues inspiring motivation for change at the community level, where even present environmental laws (considered inadequate by approximately 50% of Americans) originated, is necessary (Miller 2007; Coyle 2005). Present environmental law in the U.S. defines "reasonable environmental behavior for individuals and groups, according to the larger community" (Miller 2007). Although legislators within a democracy work with special interest groups (small, profit-making organizations, labor unions, environmental organizations) to shape policy and pass laws based on the group's cause, few political leaders have a full understanding of the interconnection of the earth's natural systems, societies, and economies (Miller 2007). In addition, election turn-around time is short for the politicians, so they focus on short-term projects despite the fact that most environmental issues (climate change, biodiversity decline) are long-term problems requiring long-term solutions (Miller 2007). Analysts have defined nine guiding principles for policy makers to shape more beneficial and successful laws. These include the *polluter pays principle*, developing green taxes to ensure that the polluter 'feels' the effects of waste produced and encourage waste reduction, the *integrative principle*, accounting for the interconnectedness of the earth's systems, and the *public participation principle*, facilitating an increase in public participation in the decision making process as the community's citizens will be affected by policy change (Miller 2007).

"An informed and involved local community always does a better job of environmental protection than some distant protection" (Skanavis 2002). As they cannot experience the ramifications of environmental problems, distant managers fail to perceive them and policies are not adjusted appropriately; successful policy changes come about by working with local landowners (Diamond 2005). Economic

class divide insulates the elite from the "consequences of their actions", thus they are more likely to disregard the implications of their actions on other economic groups (Diamond 2005). For example, watershed contamination due to waste from of the Zortman-Landusky gold mine in Montana, USA was not appropriately addressed as the mine directors did not live downstream (Diamond 2005). In another case, the personal experience of a Chevron manager, assigned to clean up oil pits in Texas, USA, allowed him to finally learn the economic value of clean environmental policies, as the clean-up of the smallest pits, on average, cost US$100,000 (Diamond 2005).

Ex-Executive Vice-Provost at Colombia University, USA, Michael M. Crow, moved to become the President at Arizona State University (ASU), USA because he wanted to make sustainability a core value of a university in a water-starved landscape – he believed that the best way to do make a difference was to experience the environmental problems first hand (Monastersky 2006). And even after he eventually leaves ASU, Crow believes that the sustainability initiatives at the university will continue because of the environment – in the middle of the Sonoran Desert, the environmental issues can be felt directly; over the past 20 years, there has been a 12°F rise in temperature (Monastersky 2006). Universities need to become forces in local policy change, connecting people across disciplines, merging engineering, economics, science, and politics (Monastersky 2006; Fogg 2006). Non-traditional methods of environmental education, involving an inter-disciplinary approach, allow us to personally experience the effects of environmental policy and may spark motivation for change, and, since we retain 90% of what we experience, may have the most long-term educational and environmental benefit (Stone and Barlow 2005).

5. Conclusions

Despite the myriad of benefits of non-traditional methods of environmental education, environmental science/studies programs face criticism, suggesting shallow, hyper-diverse, and incoherent curricula and lack of vision, for their multi-disciplinary nature, and even some students find reason for doubt (Allen-Gil et al. 2005; Josephs 2008). With the fast-paced mentality of the American society, a multi-disciplinary program provides only enough credit hours for a basic understanding of the numerous subject areas that can be encompassed in such a program (Josephs 2008).

A student of this 'general' model of education may wonder: will I be competitive in the job market? Would a more 'focused' program, one that hones my skills in a particular area while broadening my understanding of its connections to many other disciplines, serve to make me a better, more informed policy maker? Which program style will provide more significant and appropriate qualifications to solve the problems of environmental security? Which style has higher value in our society? If, currently, the value is on a more focused approach, will this opinion shift with a paradigm shift, a desegregation of academic disciplines, in our education system? Will employers need convincing that environmentally educated

graduates have the proper knowledge to enter the work force through this transition period (Fogg 2006)? Which approach to environmental studies is better for students' breadth of understanding? Which approach will be more effective at ensuring environmental security? Which approach is better for our global society? These questions are crucial to deciding whether or not to implement non-traditional methods of environmental education and also deciding what form this education takes, 'general' or 'focused'.

As we move into a decade that requires a heightened and more attuned sense of environmental security, a more 'sustainable' education, one that embraces non-traditional methods of environmental education and a systems-thinking approach, is necessary. Through this shift, we aim to increase environmental awareness to the point of achieving environmental literacy, "the outcome of a sound program of environmental education through which the learner progresses from deep knowledge, to skill, to actual field application" (Coyle 2005). Students of this non-traditional education better understand their roles within the immediate landscape and thus make the most beneficial policy decisions for the region. For some students, the benefit of non-traditional methods of environmental education compared with traditional methods is hard to articulate (Stumpf 2008). The opportunity to understand a personal connection with the environment is one that inspires engagement with the subject and makes the material more comprehendible and meaningful. Rather than something students memorize, the course materials becomes something that the students experience, thus shifting the vantage point for the rest of their lives. As environmental education "cuts against the grain" of traditional practices of higher education, this shift will not happen over night (Bardaglio 2007). Rather, finding a solution to "environmental illiteracy" will require work over time, encompassing many complex changes within many fields of our society – just as the solution to any environmental or sustainability dilemma.

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TOWARDS INTEGRATION OF KNOWLEDGE THROUGH SUSTAINABILITY EDUCATION AND ITS POTENTIAL CONTRIBUTION TO ENVIRONMENTAL SECURITY

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Abstract: This paper reports on 10 years experience with a model of sustainability education within a series of required, integrative and interdisciplinary undergraduate courses. It is based on the collaboration of faculty, students, staff, community members and agriculture and food industry stakeholders. It describes the pedagogical experience of a Community of Learners pedagogy that requires a collaborative organization of research and learning. It pays particular attention to the context of knowledge and to the relationships between learning objects and their environment, a combination that I call an ecology of knowledge. The proposed ecology of knowledge considers that content of education and the process, or mode of its delivery, are inseparable and shape each other. Also, it highlights the relations between personal and community experience of problems, scholarly accounts of those problems and visions of potential futures, to overcome the problems, as three cognitive moments that strengthen each other. Sustainability education is critical if society is to address threats and challenges to environmental security. The goal of our model of sustainability education is to form citizens-learners with environmental awareness, professionals with vision and tools to address problems, carry out research and create solutions. Although systematic investigation of our experience is beginning only now, we have evidence that the model is successful in delivering a set of specific, yet ambitious sustainability education learning outcomes.

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1. Introduction

Institutions involved in the production and dissemination of knowledge, such as universities, all too often promote a reductionistic culture that objectifies and simplifies reality, fragmenting it into isolated independent parts while at the same time disconnecting people from each other and from nature's complex interrelations. In doing so, they fail to deliver the education necessary for the transition to a sustainable civilization. I identify the implications of the fragmentation of knowledge together with its consequences for environmental security, based on 10 years of experience of curriculum change and the exploration of a collaborative organization of knowledge, the "community of learners" pedagogy, at the University of British Columbia (UBC), Canada. This experience is placed within a series of required integrative, interdisciplinary undergraduate courses, involving collaboration among faculty, students, staff, and agriculture and food industry stakeholders. Here, I report on specific experiences of delivering a university education aimed at facing the challenges of environmental security by training/ educating sustainability leaders who can act upon systemic vulnerabilities such us those threatening food security. Sustainability leaders are citizens with heightened environmental awareness, and professionals endowed with vision and tools to define the problems, research them and find and implement solutions.

While this is the story of a particular place at a particular time, it is a story with wider implications. Most certainly, it is about experiences that will have implications elsewhere, where similar changes have happened or are happening. It is about knowledge and information, creation and dissemination aimed at transitions to sustainability. Based on these experiences, I argue that educating sustainability leaders requires an ecology of knowledge that considers that the content of education and the process of learning that content, shape each other, and in fact are inseparable. This ecology of knowledge also pays particular attention to the relations between personal experience of problems, scholarly accounts of those problems and visions of potential futures as three moments in the formation of knowledge that strengthen each other. It also requires a learning process that encourages learners (students and faculty) to develop "polycultures of the mind", where education is a mirror of the complexity of life, thus, learning ***with*** life, to understand that behind agriculture and the way we feed ourselves, there are particular ways of seeing and thinking.

Sustainability education is a critical component of societal responses in the face of environmental security threats and challenges. Sustainability education represents both a critique of the current knowledge base and a direction for its transformation. It intends to create citizens with environmental awareness, leaders endowed with vision and tools to define the problems, to research them and to offer solutions.

I propose that a key condition to overcome the disconnection between people from each other and from nature through education, is to pay particular attention to the of relationships (social-cultural and ecological) that link any learning object with its context, because relationships transform both the knower and the known. The notion of "ecology of knowledge" echoes Gregory Bateson's "Ecology of the Mind", which called attention to the cognitive and emotional aspects of ecological knowledge (Bateson 1972). Bateson's theory called for a "necessary unit" between mind and nature (Bateson 1979), that should include consciousness and rationality as inseparable from the deep emotional side of humanity. I argue that personal experience, metaphors, ideals and a poetic sensibility are indispensable components of the ecology of knowledge and must be integrated into pedagogical designs and processes. However, these must be checked constantly with empirical evidence, open to peer review and, at the same time and conversely, be used to check excessive and excluding claims of rationality.

This paper has a distinctly testimonial flavor and points out to both moments of success and moments of doubt and uncertainty in our work. The experiences are local, but the issues are global. I begin with a general discussion on sustainability education and environmental security, followed by a brief description of the process of reform at the Faculty of Land and Food Systems at the University of British Columbia, the site of the experiences reported in this paper. This focuses on the Faculty's interdisciplinary integrative academic core provided by three courses that form the Land, Food and Community Series (AGSC 250, 350 and 450). Then I describe curriculum content and highlight some learning activities that we have found to have particular pedagogical value in sustainability education. I conclude with some reflections about the experience and provide some of the main insights we have gained, including challenges, obstacles and uncertainties about the future direction of our experience.

2. Sustainability Education and Environmental Security

A key assumption about sustainability education is to embrace the responsibility to prepare human society for cultural changes required to attain a lifestyle in which human society can adapted to the constraints and possibilities offered by the biosphere and by the biological communities where we dwell. This is the grand challenge of an education that embraces environmental security at all levels as its aim. But what kind of education will deliver the promise? As David Orr (1994) pointed out, it is not just more education, but an education of a certain kind: an education that is fundamentally, environmental education. And, in our case, this is an environmental education for making food compatible with environmental security and sustainability.

2.1 THREATS AGAINST ENVIRONMENTAL SECURITY: THE CASE OF FOOD SECURITY AND FOOD SYSTEMS SUSTAINABILITY

In our case, we have addressed environmental insecurities and the vulnerability of human communities caused by the threats against food security and the sustainability of food systems at all levels. Food security is defined as the condition made possible by a food system that delivers food that is affordable, available, accessible, appropriate, safe and sustainable for all.

Our goal has been to develop a better understanding of the impacts of large forces (e.g. climate change, loss of biodiversity, depletion of natural resources, forms of production, distribution, consumption, disposal of end products and environmental and social impacts of food) on the global food system. The latter is characterized by a continued growth in food production and by a trend towards specialization by comparative advantages for liberalized trade. These trends, however, have not alleviated widespread malnutrition nor reduced severe environmental impacts on the food system. In fact, these trends (supported by a particular way of thinking and knowing) have caused growing impacts of the food system, placing agriculture among the most environmentally disrupting industries. The global food system has failed to provide sufficient food for everyone. There are around 4 of the 6 billion human beings on the planet suffering from malnutrition, with roughly 2 billion underfed, of which some 800 million suffer chronic hunger, yet at the same time, 2 billion are overfed (Nestle 2002; FAO 2008). Nutrition and food experts are alarmed by the continued growth of both chronic hunger and obesity, both forms of malnutrition affecting all ages (Lang and Heasman 2004; Wang 2001; Beydoun and Wang 2007). The impacts and demands of our globalized food system on energy, water and the environment in general, and on traditional food systems and labor, are increasingly unsustainable, raising serious concerns about its viability.

Global climate change is affecting every single factor in the production of food from water and soil to biodiversity, and will dictate many key food production decisions (IPCC 2007; Brown 2004; Lang and Heasman 2004). Increased temperatures and severe fluctuations (drought, flooding, storms, etc.) stress essential ecosystems and affect entire regional food systems. Even the most self-reliant food system can become vulnerable if its links with others are weak, thus making emergency and crisis intervention more difficult.

2.2 TEN YEARS OF REFORM

Ten years ago, the Faculty of Agricultural Sciences (now renamed the Faculty of Land and Food Systems) at the University of British Columbia, Vancouver, Canada, was experiencing a process of “dis-integration” in the double meaning of the word. First, the Faculty was “disintegrating” institutionally because the organization was in crisis: student enrolment was down, morale was low, and the university was demanding a rapid response and adaptation especially from small Faculties. However, equally or perhaps even more importantly, was the other “dis-

integration", in the sense of a ***lack of integration*** of the body of knowledge the Faculty was producing through its research and curriculum. Research and teaching were marked by a lack of dialogue and cross-fertilization between the program specializations, and by an organizational culture that fostered isolation among its members. Moreover, the Faculty of Agricultural Sciences was failing to address the larger problems of agriculture and food.

What resonated in the Faculty of Agricultural Sciences were the problems, limitations and inadequacy of knowledge based on the dominant scientific reductionist, Newtonian-mechanical paradigm. This knowledge base had contributed to many of the successes of agriculture (e.g. the impressive growth achieved in post-WWII food production), but at the same time it had created many of the major problems that had made agriculture one of the most environmentally harmful human industries (IPCC 2007, 2008; Brown 2004; Land and Heasman 2004; Altieri 1995; Gliessman 2006; Pretty 2007).

As elsewhere, discontent led to creativity. A group of faculty members were asked to transform these challenges into opportunities for change. A new Dean, trained as a landscape ecologist was appointed to bring about the necessary transformation. Dean Moura Quayle's vision, together with her inclusive and charismatic leadership style, opened the door for rapid change. Sustainability (including controversial aspects) moved to the centre of the new Faculty's mission, shaped its Core Values (Gudz 2004), and became the guiding concept for the complete transformation of the curriculum content and its pedagogical mode of delivery. This was also a time of a wider re-structuring at UBC as at other Canadian universities, and the emergence of a sense of urgency to create and disseminate knowledge aimed at sustainability.

During 1997–98, responding to a series of consultations with the agriculture and food industries of British Columbia, new learning outcomes for the Faculty and its undergraduate programs were developed. This involved many meetings and a close examination of past course offerings and learning outcomes, including a review of administrative structure, academic programs, the role of information technology, and the creation of a Learning Centre to train faculty, students and staff in the use of electronic resources. The new program officially began in September 2000.

2.3 THE COMMON ACADEMIC CORE: LAND, FOOD AND COMMUNITY

Although UBC and the Faculty of Agricultural Sciences have been the site of a range of sustainability initiatives (both, academic and campus-based) (Gudz 2004; Moore et al. 2005; Rojas et al. 2007; Sipos et al. 2007), this paper focuses on the experiences of the Faculty's Land, Food and Community (LFC) series. We chose this focus because its creation was conceptualized as a key step in the reintegration of knowledge, and to form global citizens endowed with "big picture thinking". It was also a unique opportunity to take advantage of the wide range of disciplines within the Faculty. These disciplines included landscape architects and

ecologists, agricultural economists, and all the traditional agricultural specializations in plants, soils and animals now transformed into new programs of Agroecology, Food, Nutrition and Health, Food Resource Economics and Global Resource Systems. The academic core was then created through a series of three required undergraduate courses totalling 15 credits: AGSC 250 (6) Land Food and Community I, AGSC 350 (6) Land Food and Community II, and AGSC 450 (3) Land Food and Community LFC III. Later it was decided to include a one credit introductory course, AGSC 100 in the series, to introduce students to the Faculty and its academic philosophy.

These four courses, the Faculty's core curriculum, were unique in many respects. Through this series, over 1,500 undergraduates and the broader "community of learners" (faculty, undergraduate and graduate students, staff and community members) have studied local food system sustainability within global contexts, primarily using community-based action research (CBAR) (Stringer 1999; Freire 2000; O'Brien 1998; Fals Borda 1998; Levin et al. 1998) to investigate problems and strategize change, all of which reflect the Faculty's new Core Values (Gudz 2004).

2.4 GOALS OF THE LAND, FOOD AND COMMUNITY SERIES

The Land, Food and Community (LFC) series encourages interaction amongst undergraduate students, graduate students, faculty, instructors and researchers within the Faculty, the university, and in the broader community. The goal of the LFC series is achieved through a pedagogical approach and learning environment that I call the "Ecology of Knowledge" which helps people to understand "how we know what we know". "Ecology of Knowledge" refers to how knowledge is created and re-created in the diverse contexts in which it emerges, as well as how it is distributed and shared. The key notion of the ecology of knowledge is to pay particular attention to the relationships among any learning object and its multiple surrounding influences (i.e. a study of healthy diets needs to examine the quality of the soil, water and air and the health of the ecosystems that sustain that diet). I have interpreted the mind and nature unit which Bateson (1972) speaks of in his argument for an ecology of the mind, as a challenge to create learning experiences and settings that cultivate what I call "polycultures of the mind" (a multicultural mind). That is, knowledge that attempts to mimic and to assimilate the complexity and uncertainty of life, accompanied of a learning process that stimulates mind openness, through viable and feasible learning outcomes. In the LFC series, we foster a learning environment that values diversity, encourages excellent oral, written and electronic communications skills, and cultivates the ability to work creatively and cooperatively in team settings.

2.5 LEARNING OUTCOMES FOR THE LFC SERIES

Upon completion of the LFC core courses (AGSC 100, 250, 252, 350, and 450) students are expected to be able to define, evaluate and apply the concepts of:

1. Agriculture and food security with respect to affordability, accessibility, appropriateness, availability, sustainability, and safety of food
2. Systems, interdisciplinary, participatory, and multi-stakeholder approaches to investigating issues in land, community and food systems
3. Linkages between food, nutrition, health, food and resource economics, and agroecology in the local, regional, national and global context
4. Interactions in the food system cycle (production, processing, distribution, consumption, resource recovery, and management of "waste" materials) affecting human, animal and ecological health
5. Relationships within which knowledge is embedded, that is, the Ecology of Knowledge
6. The impact of policy on agriculture, food systems, and human and ecological health
7. Value assumptions behind research paradigms, problem definitions and methodologies, and understand the implications for policy-making
8. Genetic theory and applications as they relate to agriculture and food systems
9. Statistics as they relate to agriculture and food systems
10. Develop skills in critical thinking, personal management, leadership, team building and problem solving in a multicultural and diverse context
11. Participate effectively in a community-of-learners and become citizens concerned with the broad challenges faced by contemporary society
12. Acquire professional verbal, written, visual and electronic communication skills.

Faced with the task of helping our students achieve the above Learning Outcomes, we worked with the underlying general assumption that no one has all the expertise required by the scope of the LFC series. It was decided to form a team of instructors representing a wide range of academic backgrounds. The scope and complexity of the problems required the mobilization of a broad array of intellectual resources from the Faculty and the input of experts in many field. Thus, there was a need for a community of learners. The wide scope and integrative impetus of the series was provided by a systemic perspective. This allows us to address the entire food cycle, from production and the quality of the soil, water and air at the farm, through processing, marketing and policy-making, to distribution, consumption and finally disposal. Nor do we neglect the environmental impacts of the whole cycle and its end products. Several case studies have been developed for in-depth examinations of specific productive sectors (e.g. the dairy system), field trips to conventional and organic farms, and evaluations of their respective social, economic and ecological sustainability.

Besides the case studies, we have two long-term community-based action research projects which are designed to overcome the separation of research from teaching, and the classroom from the environment and surrounding communities. The first project was the "Food Security of the City of Vancouver Project", which

later expanded to become the "BC Food Security Project". This was initiated in 2001 and partnered our second and third year LFC students (AGSC 250 & 350) with community organizations throughout the province involved in food security assessments. The overall objective of the project is to contribute to food system enhancement. More recently, a strong community-service learning component was added in collaboration with UBC's Learning Exchange (Sipos 2009). Students spend a significant amount of time out of the university in the most vulnerable communities, investigating where food comes from, and how is it produced, consumed and disposed of at the end of the productive cycle. The students' ideas and recommendations later contributed to the creation of a Food Policy Council for the City of Vancouver. As a result, the realties of the communities and questions of food policy have become a central part of our curriculum.

The second long-term project is in AGSC 450 – the "UBC Food System Project". This was initiated in 2001 by the Faculty of Land and Food Systems and the UBC's Sustainability Office. The result of this project is a university-wide transition towards a sustainable UBC food system (see Rojas et al. 2007).

These two community-based action research projects contribute greatly to the LFC series as models for collaborative learning and innovative research environments. Students in the LFC series engage with a range of issues related to food security. The series is built upon an integrative framework that incorporates learning and research at its core, organized through a process that emphasizes optimisation of team work, interaction among students, graduate student teaching assistants and faculty, along with extramural activities linking students with wider communities.

A collective memory is stored across years through the course websites, and a system of continuing interactions involving teams and team members through online dialogue. In this way, incoming students build on the work of students from previous years. The establishment of a Learning Centre provides sustained support for online resources for sharing data and an increase of interactions of student teams with faculty and graduate students. Thus, thousands of online interactions complement the in-class work of teams on campus. Besides the resources, results of team research and instructor feedback are available to each incoming generation of students. We plan next to make these materials available to the public.

2.6 THE IMPORTANCE OF PARADIGMS

Since the inception of the LFC series, systematic efforts have been made to help students understand and appreciate the importance of paradigms, values and critical thinking in scientific research and in professional practice, especially those related to sustainable food systems and community sustainability. We encourage conversation with the whole class early in the course, asking students (and ourselves) questions such as "What has the global food system delivered? What way of seeing and thinking is behind this food system?" "How do we know what we know?" "How do we identify what we do not even know that we do not know?"

"How does the context of knowledge influence learning?" "How do personal stories and the communities and cultures we come from influence our academic interests and professional goals?" These questions are used to elicit dialogue and convey the practical importance of "ways of seeing" (epistemology) and its companion values and ensuing ethical basis. Without embracing any particular rigid epistemological position, the Land, Food and Community series explicitly encourages students to learn to "think out of the box" of their specialization, and to overcome discipline "tunnel vision". We introduce students to the idea that fragmentation of knowledge and over-specialization needed by industrialization, and the consequent inability to see the entire picture, are ultimately key contributors to the crisis of agriculture and are behind the unsustainable nature of our contemporary civilization.

2.7 THE TEACHING TEAM

The core LFC team has been stable and our collaboration has fostered a deeply rewarding and long lasting intellectual and effective shared adventure. The teaching team depends on the support of our graduate students, each responsible for facilitating the work of several undergraduate student teams.

Every week, the class sessions unfold through shifts between learning modes – regular classroom time when the entire class is together, and team work. When the class is together, interactive lectures never take more than a third of the whole session. But in those sessions, concepts and complex theories are checked against the personal experiences of the students, through brief interactions in pairs or triads. Then, students break into small teams of around six to eight members, to work in separate breakout rooms, where the fundamental collaborative work takes place. In every session, the required readings for the day are discussed, presented by the teams with an emphasis on the students' critical appraisal of these readings. This allows ample time for the teams to work on their collaborative real-life case studies.

2.8 THE DYNAMICS OF THE COMMUNITY OF LEARNERS AND THE STEPS TOWARD AN ECOLOGY OF INTEGRATIVE KNOWLEDGE

We soon realized that true innovation in the pedagogical mode of delivery of a new curriculum required a heightened attention to the "hidden curriculum" (Ballantine and Spade 2001). I mean by this, the actual context (including the physical context) in which it is delivered, as well as the type of interactions that take place during the act of learning.

Another important realization was that what UBC (and all other universities) used (and still use) as the most frequent or "normal" way of delivering its curricula was by no means sensitive to the diversity of learning styles, cultural experiences and life history of students and faculty. The "normal" pedagogy is passive, teacher-centred. There is sufficient research to show that this approach supports neither the principles of adult learning nor higher order thinking (Bloom

1956). While ideological pluralism, tolerance and respect for human rights are advocated in most campuses, the setting and physical layout of the spaces where these ideas are advocated, the relations of power that shape it, and the competitive dynamics within which learning unfolds, inevitably recreate top-down dynamics that result in limited learning. Certainly, smaller classes usually allow for more intimate and personalized relationships, but even those are too often, arenas of relatively overt competition for prestige. People feel that they have to be guarded and must protect themselves. We decided to address this challenge head-on and probed ways to create a truly safe learning environment where both instructors and students would not be afraid of saying "I do not know…but let's find out together".

In the LFC series, two thirds of the classroom time consists of team-based work. However, students usually feel that they need to spend time together outside the classroom not only to work collaboratively on their assignments, but equally importantly, for creating and deepening a network of interpersonal support. Each year, the overwhelming majority of students indicate in their course evaluations and feedback how critically important are the participation and collaboration in the team, where providing confidential peer evaluation is a requirement. Of course, there are students who prefer to work alone, and are reluctant to accept that a community of learners, ***under the right conditions***, produces a different kind of knowledge that truly enhances individual expression, critical thinking and creativity. They do not realise that such work leads to feelings of joy and satisfaction in the learning process which often leave a deep imprint on the student's life. So what are these ***right conditions?***

2.9 THE INTRINSIC VALUES OF DIVERSITY

One of the primary underlying assumptions of the "community-of learners" approach is that the diversity within our classroom is the most precious learning resource available to instructors and students. The dynamics of difference open new and richer vistas to any subject matter. To be enriched by cultural and professional differences, people do not need to become ethnographers or experts in all fields of knowledge. It suffices if they understand what happens to "some-thing" (any thing or any learning object) when looked at from a multiple-perspective provided by the movements of a "video-camera". We work with the idea that every cultural perspective, every theory of reality, every academic discipline, every philosophy, every religion, every paradigm and every ethical position provides a particular angle of the "camera" which illuminates something new. No single angle can capture the totality of the "some-thing", but the wider, finer, and more varied the camera movements, the more complete the image obtained of the ''some-thing'' and the better our understanding of "it". There are many explanations for this, but perhaps the most important is that nothing exists independent of the ways in which it is seen. The thing observed is shaped by its relationships to its surroundings, while at the same time, it feeds back on its context.

Of critical importance for the success of the collaborative learning process involved in the community of learners is ***valuing diversity beyond mere tolerance of it***. This is followed by a positive appreciation of it, not only as ***natural*** and ***inevitable***, but as ***desirable***. Why desirable? Because our capacity to know the world is limited and every perspective contributes something extra to explain it if presented in dialogue. None of us has the capacity of knowing the whole phenomenal complexity of the world; therefore claims of access to total truth are always sources of authoritarianism and have potential for delusion.

Needless to say, to ask for an appreciation of diversity that not only tolerates it but celebrates it, is easier to say than to achieve, especially in the classroom. The practice of this principle requires endless patience, personal vigilance and the ability to truly listen to others, paying full attention while suspending judgment. So the challenge in a learning environment is to develop forms of group facility-ation that ensure individual contribution and expression have equal opportunities. To improve group dynamics, as soon as we form working teams, students are assigned the task of creating a set of consensually agreed upon "ground rules" for their team. These rules govern the team's functioning throughout the semester, unless group consensus decides to change them.

The diversity that we consider must be valued positively ***is multifaceted***. It refers to diversity in both cognitive and learning styles – in other words, diversity of strengths and limitations, diversity of professional and academic backgrounds, diversity of skills, diversity of spirituality and religion, culture, ethnicity, race, age, gender, sexual orientation, class and general upbringing. We have found students rapidly and readily discover each others' strengths and weaknesses through several experiential exercises based on differences and commonalities. These exercises (more later) speak to them more eloquently than any thousand words of the professors.

2.10 ACTIVITIES THAT DEMONSTRATE THE PEDAGOGICAL VALUE OF DIVERSITY

In this section I will discuss specific examples of classroom activities whose objective is to create opportunities to experience the expression and learning value of diversity. These activities illustrate complex problems in the philosophy of knowledge, avoiding excessive abstract conceptualization and concentrating instead on their significance experienced with the aid of images and metaphors.

1. **Visual aids:** Early in the course we show "Zea", an impressionistic 5-min film based on pure images and music, devoid of context or scale. It allows the viewer to take a journey of interpretation of what he/she sees through the unfolding of beautiful colours and shapes and music. The students are asked to take notes describing what they see as the film progresses. Afterwards when exploring what each student has observed at the various moments, the exercise reproduces (without any need for jargon) many of the important dilemmas of the theory of knowledge and the debates that philosophers often make

inaccessible to ordinary people. As a result, the students' observations acquire relevance and significance through contrasting their personal perceptions. In the end, when they discover what they were actually viewing (i.e. a frying pan with boiling oil and popcorn on which the camera was zooming in and out through the bubbles, with a musical background) give all participants a hint of a personal breakthrough: the demonstration that we spontaneously see, feel and think differently, and perceive different things even when given the same data. It is an effective demonstration that the observer is an active creator of what is observed.

2. **Diversity of backgrounds:** We employ various exercises that introduce students to the reality and consequences of diverse backgrounds, whether these are cultural or related to academic interest.
   (a) One of these exercises is the "True Colours" workshop given by UBC Career Services. It runs for 4 h and allows students to identify their most salient personality traits in relation to a set of specific situations. "True Colours" represents attributes that students find they share with, or which differentiate them from, their classmates. Different coloured playing cards represent working styles, inclinations towards leadership, forms of knowing and doing that are most comfortable, notions of efficiency and style of communication, etc. The students are always surprised by the diversity of cognitive styles, and learn that team members bring an array of skills and talents to the group: some are great listeners, others great speakers, some are excellent organizers and others are visionaries. Their challenge is to draw on that diversity of skills and strengths to optimize team performance. Exercises are provided in these workshops that allow students to compare their individual performance facing a complex task with their team's performance, and so experience the value of collaboration.
   (b) The Barnga Game (Thiagarajan and Thiagarajan 2000) and the experience of cultural diversity is another simulation game. Students are provided with instructions to play a simple card game. They are seated at a dozen tables and told that winners will move to tables of higher numbers and losers to ones with lower numbers. After practicing and learning the rules, printed instructions are collected and speaking and writing for communication among players are forbidden. Based on their previous experience, participants are confident they can play the game, know the rules and know how to win. However, they are not told that the initial instructions given to each team were slightly different, and soon confusion and frustration appear, which often develops into unspoken conflict. The teams are then debriefed and it becomes clear that the game is a metaphor for experiencing another culture ("rules of the game"). This experience vividly and experientially demonstrates that if we assume that the new rules of "game" are already known, then we are likely to make serious errors when adapting to a new cultural context. This assumption also equally affects both newcomers and members of the mainstream receiving culture. The discussion following the game is always impressive and profound.

Following these experiences (that take place early in the course) 30 working teams in a class of 200 students are created to optimize diversity, especially diversity of academic specialization. Instructors set the tone by sharing their personal stories about the communities in which they grew up. Students do the same in their teams. Then we gather together to discuss the notion that to ***value diversity positively is the opposite of not talking about it***, as in the caricature hidden behind the notion of "political correctness" that encourages silence about differences as the polite way to go. We encourage the students to consider that our real challenge is to find ways to prevent difference from becoming the basis of discrimination and barrier to equal opportunity. Thus, conversation and debate within a safe and respectful environment, together with critical thinking, appear key for learning about complexity and uncertainty.

3. Flashlights in Dark Forests: Experiencing a Paradigm

This exercise represents a true discovery for the instructors in terms of what integrative learning moments can accomplished. To illustrate the value of combining diverse ways of seeing, students are asked to consider different perspectives and ways of seeing (paradigms) as equivalent to using flashlights of different strength and degree of focus, to find their way through a dark forest.

Their instructions are: "You and your team are placed in a dark forest and must find your way out. The team has the possibility of choosing from different flashlights. Some may be very powerful with narrow beams of light; others may be weak and diffuse. Still others may illuminate wide sections of the forest, but not reveal details". To simulate that scenario, we turn off all the lights in the classroom and ask the students to envision the situation. Then one by one, we turn on different types of flashlights, moving them through the room while asking the students to describe (after a short dialogue with their neighbour) what they see with each flashlight. Then we ask them to describe what they see without any flashlight and what flashlight they would choose under those circumstances. Finally, we turn all the flashlights on and direct them into different objects, separately and together. We alternate this with total darkness, allowing time for their eyes to get adjusted to the darkness. Usually students describe the following situations:

- The stronger focussed beam allows the observer to see many details with great clarity within the spotlight. However, we observe that the stronger the beam and the focus, the darker and more impenetrable the surrounding forest seems to be.
- Conversely, a wider focus and softer beam may give a clearer view of the background but a very fuzzy view of details and components. Although some of the richer immediate details of our path may be missed, we may now be aware of the surroundings that the highly focused flashlight prevented us from seeing.

- Probing almost blindly as we walk in the dark forest without any flashlight initially prevents us seeing anything at all, and usually is an option that we do not favour.

We also ask the students to consider and speculate what would be the experience of the inhabitants of the forest, whose familiarity with the place likely would allow them to find their way without a flashlight. The forest people wait until their eyes get used to the dark and so confidently find their way that they know so intimately. They know the type of soil they are stepping on, the moisture, the direction of the wind, the sounds of animals, the position of plants. They can walk barefoot with no more than the light of the stars or the moon, and wait safely if necessary, with no fear, until dawn. They may not need a flashlight or even not know about its existence.

3.1 DEBRIEFING THE DIVERSITY EXERCISES

At this stage, the class is invited to discuss all the exercises on diversity. They are invited to "imagine every way of seeing as a particular set of lenses" that will give the impression of a paradigm. This emphasizes that paradigms are collectively shared assumptions and ways of seeing, and are not the same as an individual opinion. Questions and areas we consider in this discussion include:

- We begin by asking: "Is it possible to use the different flashlights to illuminate a learning object?" The students usually recognize the difficulty of doing that individually, but learn with the experience that it is possible if it involves the organized collaboration of a team. Their experience illustrates the value and strength of interdisciplinary collaboration. It also reveals **the emergence of dimensions** of the "forest" (the learning object) that could not be seen by using only one type of flashlight, even if these were several of the same quality. We then compare their experience to what was learned from assigned readings that contrast paradigms of food and agriculture by displaying in parallel, views of different agricultural production systems (e.g. a modern monoculture and a traditional peasant polyculture).
- The second question is usually: "Is the knowledge of the "inhabitants of the forest" important to scientists?" We reflect on assigned readings that document the nature of traditional ecological knowledge of peasants and traditional farmers in many Third World countries, together with the type of agricultural practices that their type of knowledge has created. To survive, these traditional farmers require a profound and detailed practical knowledge of their local ecosystems. They are rooted in their places, which leads them to a type of knowledge that is involved and participatory, rather than detached and remote. It is also subjective and value-laden, because it overtly appreciates personal experiences and beliefs as resources for knowledge, rather than as obstacles. It is centred on the interests of the

local community and its aim is to produce food for the local communities, with the goals of sufficiency and long-term stability, rather than fast profit and production for foreign or remote markets over the short-term.

- Traditional ecological knowledge is also experimental and is always experiential. However, the experiments that peasant farmers conduct are experiments **in situ** (they take place in their natural context), **not in vitro** (in an artificial context) as in most standardized scientific experiments. The latter approach, purposefully and systematically controls the environment to identify the cause of the single effect under investigation. The former remains by necessity more open-ended and evolves through trial and error, often involving several simultaneous effects.
- By comparing Western scientific knowledge with local, experiential knowledge, students can realize that the requirements of these types of knowledge tend to be very different. Science was born and has evolved mainly from the interest of finding **universals** – that is, the ability to make generalizations about phenomena. So scientific research looks for **regularities and uniformities** of phenomena that can be **replicated under controlled conditions**, and such findings have been among the greatest contributions of Western Science. Traditional knowledge, on the other hand, tends to be **site specific** and **grounded in place**; **it seeks singularities and does not claim validity beyond the place where it evolved in local ecosystems**. Thus, both systems of knowledge illuminate different aspects of reality and have their own demands, merits and weaknesses, depending on the aspect of reality they intend to illuminate. What is particularly interesting though, is that science, since Einstein's Relativity and quantum physics, is documenting perceived differences. The goal of replication through experimentation is to verify shared ***perceptions of reality***.
- The key and final questions for this dialogue are: Is integration/translation between these different forms of knowledge possible, desirable? If yes, what does it involve? If not, why not?

3.2 THE INTEGRATION OF KNOWLEDGE: INVESTIGATING, LEARNING AND TEACHING IN THE REALM OF THE POTENTIAL

This involves the energy and creativity unleashed by the invitation to validate those aspects of personal life that academia usually tends to suppress or dismiss. Most scientific practitioners will readily admit that we are all subjective beings, and accept that although emotions are real, they do not help our understanding of academic subjects. Our approach challenges this notion and assumes that human subjectivity can be ignored only to the detriment of sound research. Passion, emotion, dreams, personal stories, imagination, are not only natural but real and inevitable. Their expression should not be valid only in the arts, but can contribute to all fields of scholarly activity. So we ask whether the poetic sensibility and

experiential knowledge have a place in scientific enquiry, and whether it is possible to include them in a research agenda in a disciplined manner.

Our provisional response is provided by one of the approaches we use in this course, a relatively original contribution of our own named "Learning with Life" (see Figure 1). This approach required that most activities in the LFC series and the two large community-based projects referred to earlier had been designed to explore the food systems by purposefully seeking the integration of three dimensions of knowledge: (a) personal experience and interests related to food; (b) accounts of reality as "it is" (the current situation), as represented by selected reviews of the scholarly literature on the food system at all scales; and (c) reality as "it should be" as represented by the participants' collective envisioning of a sustainable food system in general and at UBC specifically.

This approach can also be described as an investigation in the "realm of the potential": working within the creative tension existing between "personal experience and interest", "reality", and "ideal". Here, personal experience initially dictates what is relevant for students and instructors. However, the carefully planned sharing of these experiences, the team-based study and critical appraisal of the literature, and the equally carefully planned sharing of ideals about the food system, all enrich and often modify our initial perceptions of reality and unleash the imagination to uncover the "realm of the potential". This is the "desired future situation", or, what may eventually happen, but it would never happen if we had not dared to explore the utopian ideal. It is the convergence of these three dimensions that provides the "reality check" so that we neither surrender to the tyranny of "reality as it is", nor escape into impossible utopian flights of fancy.

This process of envisioning and contrasting "ideals" with "realities" permits a tempering of those ideals and a broader redefinition of what is "realistic". We name this approach "Learning with Life" because it reproduces and integrates into the act of knowing, reasoning experiences, emotions and ideals, because these are key ingredients of our lives. We are probing the notion that forms of knowledge that separate and fragment the person (reason vs. emotion) in the act of knowing, are really involved in the construction of analytical artefacts that construct reality in a particular, equally subjective way (regardless of replicability). I argue that the inclusion in collaborative knowledge of reason, experience, emotion and ideal, may give us a better approximation of the noble goal of objectivity, if what is claimed as knowledge, can remain open to the empirical verification by communities of learners. After all, our "reality" is an idea, and not the completely inaccessible Real Reality, "the thing in itself" of Kant.

Although elements of "Learning with Life" are used in different activities throughout the LFC series, it is in the fourth year capstone course (AGSC 450: LFC 3) where it is fully implemented in the UBC Food System Project. This, as explained earlier, is a multi-stakeholder, community-based action research project aimed at a sustainability assessment, design and transition to sustainability of the UBC food system. A critical reason for including the study within the "realm of the potential" is the multi-actor component of the project. In fact, without the

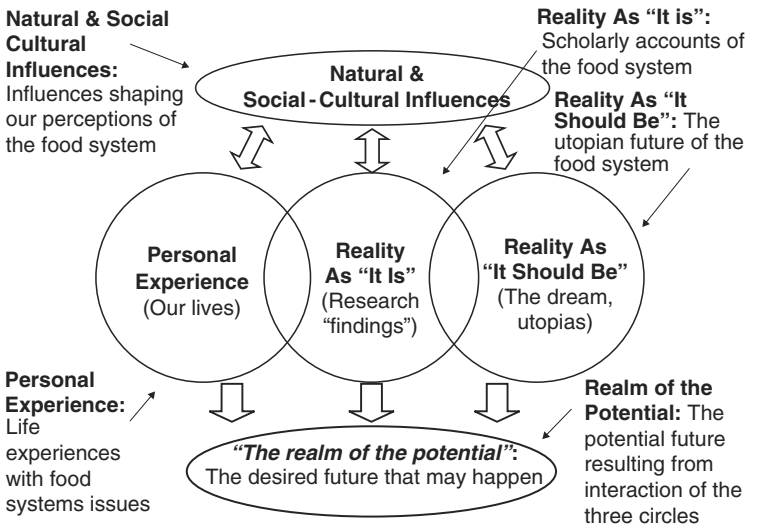

Figure 1. Learning with Life.

voices of all key actors in the food system (here, the UBC food system), the investigation remains within the limits of a purely academic exercise and its results and recommendations might have no practical application. Bringing together all key players along with their perceived problems and solutions into a "radially organized research" plan (Stevenson et al. 1994; Rojas et al. 2007), allows us to understand the institutional and structural constraints that limit process of transitioning to sustainability.

3.3 MICRO/MACROCOSMS

Another key assumption which follows from the positive appreciation of diversity is that, at any one moment, we cannot view every "some-thing" simultaneously from all perspectives. Therefore, to benefit from a "multi-perspective" view (or from the many "flashlights in the forest"), we need to find an appropriate terrain of investigation or microcosm (integrative focusing as different from reductionist focusing) that is a good representation of the larger picture we are trying to understand (in our case, the food system).

In LFC 1, the multi-perspective view is approached by means of an exhaustive examination of the BC dairy food system, from production on the farm to the table, and final disposal of its end products (as waste or resources). We consider transportation, processing, marketing, policy-making, consumption, nutritional value, health, taste (through in-class sensory evaluation of different types of milk), environmental impacts and ethical issues (animal welfare, vegetarianism, genetic

engineering, anthropocentrism vs. biocentrism). Finally, the project on Food Security in the City of Vancouver provides an opportunity to integrate and apply all the learning from the course in a real life setting. LFC 2 expands these experiences to the Province of British Columbia with a strong community services learning component (Sipos 2009).

In LFC 3, the large picture is the global food system and the microcosm that represents many of its key components, is provided by the scenarios and cases the students work with in the UBC Food System Project. Although the scenarios change every year, because each new student generation begins where the previous finished, the themes cover the entire cycle of food. For details about the UBC Food System Project and the scenarios investigated see www.landfood.ca/research/documents/rojas_UBC_Project_Overview.pdf.

This final project has provided extremely valuable learning opportunities through action research to over 1,000 students, and the actual outcomes have been implemented through many real changes in the UBC Food System (ibid). UBC campus is used daily by ca. 50,000 people, many of whom eat at the food outlets of UBC food providers. The impacts of this food system and its procurement policies on the campus environment, on the provincial food industry, and on the health of the university community, are substantial. Therefore, the UBC Food System Project has given our students and ourselves a valuable opportunity not only to learn from it, but also to have an impact on its ecological and emission footprints (e.g. the "food mileage" of foods offered on campus, its waste disposal, transportation, water and energy consumption). It is now an important component of UBC's goal to become an emission neutral institution (Ferris and Easton 2008; UBC 2008).

3.4 WHAT HAVE WE ACCOMPLISHED?

Although, at this point, we cannot report results from a systematic comparative assessment of our efforts to educate sustainability leaders, we do have reliable indicators that we are making progress in the complex task of integrating knowledge and helping students become "big picture" (systemic) thinkers. Judging by the results we observed through complex, integrative student assignments, we can state with some confidence that the learning outcomes of the LFC series have been achieved to a significant extent. The system of evaluation we have created allows us to assess students in various capacities, ranging from the need to demonstrate a command of complex concepts and theories of sustainability, through showing their ability to conduct multi-stakeholder and community-based research, to their individual capacity to participate in team work, communicate ideas with confidence to public audiences, write experiential and advocacy journals and deliver professional reports, and participate in peer evaluations of each other.

In terms of student evaluation of engagement and active participation in courses, recent data from across North America show our students rank their experiences in these two areas significantly higher than the UBC averages. They

are also among the highest in North America, although our faculty:student ratio is twice as high (double teaching load per capita) as compared to any other agriculture and food faculties in Canada (CFAVM 2007; NSSE 2006). Although we cannot claim that this is solely the impact of the LFC series, we can confidently claim that this is the result of all the efforts carried out in the Faculty of Land and Food System to deliver our learning outcomes through a student-centered, team-based, participatory and collaborative teaching philosophy.

Required, mandatory courses usually do not enjoy much popularity with the student body. However, the courses in the LFC series are highly rated by the students in comparison to other large courses in our Faculty, and the LFC courses fare better than required courses elsewhere at UBC.

Our strongest claim as a team is that we have succeeded in creating a true community of learners in the Land, Food and Community series. Year after year, we witness moving expressions of energy, enthusiasm and commitment on the part of most of our students. Of course, the LFC series is not free of pressure and moments of great anxiety to meet the demands of instructors and peers, and not all students measure up to the expectations.

The task has not been easy but it has been deeply rewarding for the teaching teams. As expected, there are problems though: the three original LFC courses represent a total of 15 credits (equivalent to five typical one-semester courses), and two of them require two 3–4 h sessions per week, gobbling between 6–8 h of weekly classroom time. Several faculty members feel this makes major inroads into the time remaining for them to cover the material of their specialization. Another problem is that few faculty members or courses build upon these core courses, despite this being a fundamental agreed upon premise in the Faculty. The last problem we face with this LFC core is its own sustainability. There are two reasons for this. Our Faculty, like other western institutions fails to replace all faculty members who retire. The second challenge is recruiting new faculty into the LFC teaching team because the university continues to privilege publications in refereed journals over teaching excellence in its tenure, promotion and reward system. To successfully instruct in the community of learners requires teachers who are passionate about collaborative teaching and learning from colleagues and students.

3.5 REFLECTIONS

Discussions about the importance of the re-integration of knowledge that appears fragmented through rigid boundaries among academic disciplines present many complex challenges. These discussions usually begin with accounts of the severe limitations of scientific and academic reductionism and the affirmation of the many virtues of holism. There is something deeply appealing in the idea that if we look at totalities we will learn much more than if we just look at parts (fragments), which are later used to re-construct the larger whole that we are trying to understand. Needless to say, to practice holism is easier said than done. Our attempt to learn to study phenomena in a holistic way does not mean to undervalue scientific

and academic disciplines. Rather, we are interested in probing the value of a type of specialization that is mindful of relationships and contexts. At the same time, we probe the value of the generalist who is confident in his/her ability to integrate wholes, but who must be aware of his/her limitations to grasp the details that reductionism provides. Our goal is to educate life-long learners (including ourselves) who are not afraid to cross disciplinary boundaries to articulate relevant questions, define crucial problems and seek how to collaborate with others to address complex problems.

What can be said about successful integration of knowledge? Perhaps the most tried form of integration of knowledge within academia is the effort of communities of peers to find or create shared conceptual frameworks and models. Communities of scholars engaged in collaborative projects spend time, energy and resources, developing shared definitions of problems, shared ways of naming things and events, and shared ways of finding out responses to the problems they consider important. Then, they report on what they have learned in academic journals that represent their shared interest. However, this honourable (and indispensable) strategy often creates new forms of fragmentation: (a) between the competing models and conceptual frameworks (ways of seeing) shared and advocated by the different communities of scholars; (b) between the different disciplines that crystalize around those ways of seeing; and (c) between the competing communities on the one hand and general public on the other. This is no one's fault, but the fault of a system of production of knowledge that responds to the needs of a given society. It is the fault of a system of training and dissemination of knowledge.

In my view, the problem then is how to overcome the fragmentation of knowledge in education and in the very production of knowledge that reproduces it, keeping in mind that specialization will continue to be an imperative. From our experience, integration requires an organizational structure that makes collaborative research and learning functional to the goals of sustainability. We have found that achieving this task is assisted by addressing personal and community experience (memory), as well as ideals (reality as "it ought to be") and approaches to the description of reality as "it is". The interfaces between these "moments" enhance creativity, enrich and deepen understanding, and enlarge the realms of the potential and the possible.

Sharing biographies and integrating them in the learning process create communities of learners who end up caring for each other, who may not just tolerate difference but even perceive it as something positive and desirable, besides being natural and inevitable. We have witnessed this happening among our students as much as it happens among the teaching team involved in the collaboration.

We have learned that situations where group members together confront uncertainty and risk can provide excellent opportunities to use a wide variety of strategies to illuminate the situation. Students, faculty and staff learn more and better when they must discover the information they need through *working together discussing problem definitions* ("what is the problem for which this research may contribute solutions or new research directions?").

We have also experimented with *specific forms of organizing for collaboration*. As reported elsewhere (Rojas et al. 2007), we have found it particularly useful to work within "Radially Organized Research" (Stevenson et al. 1994) which creates a concrete mechanism for multi-stakeholder collaboration. Another key experience has been the search for adequate integrative microcosms, or terrains of investigation, that are valid representations of larger pictures. As a team of Integrators/ Instructors we had also to learn to develop a common academic language. We have resisted as much as possible academic jargon and have worked to create both a safe and daring learning environment.

4. Conclusions

After 10 years of intensive experience, we have come to appreciate the fundamental importance of creating a safe learning environment, where zones of comfort are both respected and challenged by the discovery of somebody else's ways of seeing ("I see where you're coming from"). However, valuing diversity alone does not imply that everything goes and that there are no ways to critically assess knowledge. Space for debate and contrasting ideas is essential, and making empirical investigation a way of resolution of paralyzing differences, is a key component of the education paradigm we pursue. A safe environment is also an environment conducive to collaboration and team effort, not one where information is delivered in a top-down fashion to be passively memorized and regurgitated. A safe environment is also provided by clarity of learning outcomes, rules and expectations, by a structured learning process that has built-in flexibility (not the flexibility of not knowing what to do), and by assignments that value a diversity of cognitive moments.

It is our conclusion that teams work better when people have come to recognize each other's strengths and challenges, so that better skills are used and opportunities to face challenges are provided in non-coercive ways. The community of learners of the LFC courses is now a part of a wide network of collaboration. Our students (graduate and undergraduate) occupy positions of leadership within UBC's student organizations, are prominent actors in the sustainability movement of the university, are connected to their City's Food Policy Council and to the vast movement for food security and sustainability in Vancouver, while others occupy important positions of decision making across Canada.

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NON-TRADITIONAL PEDAGOGIES IN ADVANCED EDUCATION: ENGAGING HEAD, HANDS & HEART FOR ENVIRONMENTAL AND EDUCATIONAL BENEFIT

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Abstract: Environmental insecurity is perpetuated by advanced education through specialist-oriented, disintegrative disciplines and curricula divorced from human experience and socio-ecological context. While academic specialization is important and often crucial, embedding such knowledge within integrative transdisciplinary realities is necessary in transitioning towards environmental security and, more broadly, sustainability, as per the current UN Decade of Education for Sustainable Development (2005–2014). In this paper, I discuss non-traditional sustainability and transformative pedagogies that in combination can enable profound changes in what students are learning, and how. Based on a pedagogical approach that balances cognitive ("head"), psychomotor ("hands") and affective ("heart") engagement with the explicit aim of equipping post-secondary graduates with the knowledge, skills and attitudes integral to the development of national and international environmental security, I use the example of integrating Community-Based Research and Community Service-Learning, to contribute towards the social responsibility of advanced education to meet the needs of environmental security. I reflect upon a pedagogical experiment, underway at the University of British Columbia, Canada, that directly addresses and actively contributes towards environmental security and sustainable community development through such pedagogical integration and the lens of food system sustainability, that is, food security.

Keywords: non-traditional education; pedagogy; community-based learning; food security education

1. Introduction

Environmental insecurity is perpetuated by advanced education through specialist-oriented, disintegrative disciplines and curricula divorced from human experience

S. Allen-Gil et al. (eds.), *Addressing Global Environmental Security Through Innovative Educational Curricula*,

and socio-ecological context (Orr 1991; UNESCO 2006). This dominant model of university education in modern society is fragmented and disciplined, imparting values rooted in rationalism, the belief that that knowledge is derived from evidence-based, rigorous and scientific understandings of the world. These qualities are said to lead to objectivity, certainty, universality and predictability, but they often fall short outside of the lab and within the real world. The hegemony, or dominance, of rationalism over other humanist qualities, such as intuition, common sense, creativity, ethics, memory and spirituality ultimately has led to poverty within curriculum and schooling through the search for value-free knowledge, the goal of efficiency and the extreme focus on technology (Saul 1997). Specialized academic disconnects serve to reinforce truths that are not true at all – or very partial at best – ones that have enabled the global economy to grow fivefold since since 1950 at the expense of beleaguered ecosystems, whose 'goods and services' have been harnessed from half the world's forests, wetlands and prairies into ecologically unbounded agricultural and urban systems (Rees 2002). University-educated government and industry leaders must therefore be warned of the necessity to "rethink the relationship of the global to the local, while rebuilding public trust by engaging with social concerns" (Lang and Heasman 2004, 257). The detachment of curriculum from the human story and human condition (Phelan 2004) can be seen to contribute directly to environmental insecurity.

Renewed calls for a "scholarship of engagement" (Boyer 1996) stress the need to 're-attach', by re-orienting the Academy's three traditional pillars of teaching, research and service to the benefit of both universities and communities (Butin 2006; Marullo and Edwards 2000; Saltmarsh 1996). Such a re-orientation embeds the university within its public domain(s), and may advance accountability to stakeholders and citizens (e.g. taxpayers whom financially support such public institutions). These calls for (re)engagement acknowledge that while academic specialization is important and often crucial, embedding such knowledge within integrative transdisciplinary realities is necessary in transitioning towards environmental security and more broadly sustainability as per the current UN Decade of Education for Sustainable Development (EfSD) (2005–2014).

In this paper, I discuss non-traditional sustainability and transformative pedagogies that in combination can enable profound changes in what students are learning, and how. Based on a pedagogical approach that balances cognitive ("head"), psychomotor ("hands") and affective ("heart") engagement with the explicit aim of equipping post-secondary graduates with the knowledge, skills and attitudes integral to the development of national and international environmental security (Sipos et al. 2008), I use the example of integrating Community-Based Research and Community Service-Learning to contribute towards the social responsibility of advanced education to meet the needs of environmental security. I reflect upon a pedagogical experiment, underway at the University of British Columbia, Canada, that directly addresses and actively contributes towards environmental security and sustainable community development through such pedagogical integration and the lens of food system sustainability, that is, food security.

2. Environmental Security, Sustainability, and Education

Environmental security may be defined as "the intersection of environmental and national security considerations at a national policy level" (Allenby 2000) where the goal is "to protect people from the immediate and long-term ravages of nature, human-induced threats to nature, and deterioration of the natural environment" (Barbu et al. 2007). Environmental security is a priority for all nations based at minimum on the shared potential for global ecological collapse from the plethora of social (and thus) environmental breakdowns (Allen-Gil and Borysova 2007). Environmental security can therefore be said to emerge from well-functioning socio-ecological processes that do not compromise naturally existing biophysical limits. Such limits are not only central to broader concepts of sustainability, but fundamental to any derivative social and economic processes – thereby re-orienting the familiarly balanced Venn diagram to a nested model of hierarchically and radially arranged embedded spheres, where ecological systems form the fundamental structure (or outermost sphere) from which socio-economic systems can emerge (as the inner or embedded spheres) (Giddings et al. 2002; Rees 2002).

Within such a revised model, all education is and should be considered as environmental education (Orr 1991) that is necessarily place- and community-based, and ultimately biophysically and ecologically constrained. These values are embodied in the UN Decade of EfSD which advocates bridge-building between academia and community needs, as well as the responsibility to enact sustainability in higher education in a manner that positively affects the larger society and biosphere (Cortese and McDonough 2003). It is therefore within the mandate of universities to foster a mindset of environmental security and sustainability that prioritizes ecological and environmental health (Allen-Gil and Borysova 2007). Such a re-orientation requires a basic ecological literacy and appreciation of the interconnectedness of human and environmental health within specific contexts (Orr 1991). In the next section, I review several pedagogical models relevant to the development of leaders capable and skilled to meet global and local priorities.

3. Head, Hands and Heart as a (Re)Organizing Principle

In reviewing and engaging with the traditions of environmental, sustainability and transformative education in tertiary institutions, the framework of Transformative Sustainability Learning (TSL) was developed. Based on the organizing principle of "Head, Hands and Heart", TSL is a series of learning objectives corresponding to cognitive ("head"), psychomotor ("hands") and affective ("heart") domains of learning that facilitate personal experience for participants resulting in profound changes in knowledge, skills and attitudes related to enhancing ecological, social and economic justice (Sipos et al. 2008). Various established pedagogical models contribute to such goals and in combination; their learning outcomes may foster

opportunities to experientially investigate real-world social and economic problems that are often manifested through and contribute towards environmental insecurity. Further, such re-orientation of advanced education has the potential to develop sustainability leaders. See Table 1.

TABLE 1. An overview of some established pedagogies related to sustainability and transformative education (Adapted from Sipos et al. 2008).

Pedagogical model	***Overview of intended learning outcomes***
Action learning	A form of experiential learning that enlists peers in helping learners question their assumptions and (optimally) experience a paradigm shift before applying their learning in new situations (McGill and Brockbank 2004; Revans 1998)
Community service-learning	An educational approach that integrates service in the community with intentional learning activities. Within effective CSL efforts, members of both educational institutions and community organizations work together toward outcomes that are mutually beneficial (Hayes 2006, 2)
Community-based research	A summary of terms in social science that include aspects of social learning, involvement of participants in the research process, university and community leadership, and commitment to social change (Moore 2005; Strand et al. 2003; Coghlan and Brannick 2001, Chapter 1; Stringer 1999)
Critical emancipatory pedagogy	An ideology for learning facilitation that arises from an emancipatory tradition, focusing on equity amongst classes, races and genders (Mezirow 1997; Freire 1970)
Environmental education	An approach to teaching and learning that provides people with experience and knowledge to care for our environments (Gruenewald 2004; Orr 1994)
Pedagogy for eco-justice and community	An ideology for learning facilitation that acknowledges and finds tensions in the "industrial mindset", works to replace attitudes with the metaphor of ecology (Bowers 2001)
Problem-based learning	A framework for learning that is focused, experiential and organized around investigation of real-world problems. Authentic experiences foster active learning, support knowledge construction and integrate school learning and real life (Association for Supervision and Curriculum Development 2005; Barrows 1994)

Each pedagogy in Table 1, singly and in combination, has direct relevance to environmental security by reframing the goals of advanced education to explicitly include some form of environmental engagement, with respect to ecological and/or social systems. A thoughtful integration of key learning outcomes from each of these pedagogies that relate to the 'whole student', shorthanded by Head, Hands and Heart, may help guide the process of re-orienting advanced education

to achieve transformative sustainability learning. In the next section I discuss two of these pedagogies in more detail, focusing on those that explicitly include the community as part of the education processes and are therefore closer to engaging head, hands and hearts of the learners.

4. Community-Based Learning: Engaging Head, Hands and Heart Through Service and Research

The limitations of relying too heavily on rationalism has resulted in a call for the reassertion of humanist values and an acknowledgment of human fallibility (Saul 1997); as such "it is time to ask what we need to know to live humanely, peacefully, and responsibly on the earth, and to set research priorities accordingly" (Orr 1992, xi). To achieve this goal it is necessarily prudent to establish research priorities in conjunction with the communities that stand to be affected and to potentially benefit from the derivations. As such, community-based learning – including both Community Service-Learning (CSL) and Community-Based Research (CBR) – is slowly, but hopefully surely, gaining prominence in western advanced education as a means of attaining such goals (Strand et al. 2003).

Community-based learning in various forms is increasingly incorporated into university mission statements and integrated into a diverse range of curricula across campuses in Canada and the USA (Stoecker 2008; Butin 2006; Boothroyd and Fryer 2004; Mooney and Edwards 2001; Ward and Wolf-Wendell 2000). Still relatively young as formal academic fields (Strand et al. 2003), CSL and CBR can both be described as experiential education that thoughtfully integrates student learning with meaningful community[1] engagement[2] connected to course content via critical reflective practice (Strand et al. 2003, 122–123; Mooney and Edwards 2001) that can include journal writing, small group discussion and analytical paper writing (Fryer and Newnham 2005). In each instance, place-making and community involvement are critical in the processes of engagement and learning (Furman and Gruenewald 2004).

The literature describes both CSL and CBR as intentionally fostering collaboration between universities and associated communities and ideally enabling reciprocal learning and benefit (Bringle and Hatcher 2002; Strand 2000; Reardon 1997; Jacoby 1996). CSL and CBR are touted as having potential to embody Boyer's (1996) call for a "scholarship of engagement" that attunes the academy's three traditional pillars of teaching, research and service to the benefit of universities and communities (Butin 2006; Marullo and Edwards 2000; Saltmarsh 1996), particularly when enacted through "thick" expressions of engagement,

[1] Caveat: For brevity's sake I am referring to "community" as a monolithic entity, where in reality there are many subsets and sub-communities with whom the university can engage.

[2] Engagement in this context refers to either community service or community-based research that is embedded within processes of intellectual discovery (Boothroyd and Fryer 2004).

defined by depth and integrity, and characterized as sustaining and potentially revolutionary (Morton 1995). The combination of place-based learning, community involvement, real-world issues and applications, and out-of-class learning can lead to increasing university social engagement and relevance, student development of an ethic of civic responsibility, and community access to university resources (Bringle and Hatcher 2002). The relevance of these factors to re-orienting advanced education for environmental security is extensive. The potential to holistically and thoughtfully integrate CSL and CBR into advanced education provides pathways to engage the Head, Hands and Heart of students and community members towards effective place-based and community-driven environmental education, re-orientation and security.

5. CSL and CBR in University Food Security Education

In this section I reflect upon a pedagogical experiment, well-underway at the University of British Columbia (UBC), in Vancouver, Canada, that directly addresses and actively contributes towards environmental security and sustainable community development through the lens of food system sustainability, that is, food security. Food security is defined as access to an available, affordable, culturally and ethically appropriate, sustainable and safe food system (Bomke et al. 2004). Food systems as a focus of study provides universal connectors that are transdisciplinary in their scope, emerging from biological, chemical, physical, agroecological, health, cultural, historical, political, religious and narrative traditions, to name but a few. As such, food "has the potential of bringing together different sectors of our communities to talk about achieving food security and how to address a wide range of community issues" (Riches 1999).

Central to environmental security, universities have a social responsibility to advance sustainability generally (UNESCO 2006; Fien 2002) and food system sustainability specifically (World Food Summit 1996), in large part by way of preparing knowledgeable and skilled food security professionals and leaders equipped to rethink and rebuild the fragmented food system. Contrary to this responsibility however, the disconnects of advanced education directly contribute to extreme global conflicts over food quality, access, safety, nutrition, poverty, and the co-existence of almost one-billion underfed and one-billion overfed in an ecologically compromised world (Lang and Heasman 2004, 5). Forced dualities form the basis of traditional disciplinary university education and have, since World War II, fueled the unsustainable "Expansionist Worldview" (Taylor 1992) or "Productionist Paradigm" of agriculture, focusing on food sufficiency at the expense of quality and justice. Although the Productionist Paradigm still has widespread influence, this worldview has significantly eroded as a viable strategy for food security due to the multitude of associated human and ecological health crises (Lang and Heasman 2004, 18–19) that arguably derive from a lack of integrative and 'real-world' research and learning.

Directly in response to these disconnects, a series of community-based projects were initiated in 2001 within the Land, Food and Community series, which is the core, required curriculum of the Faculty of Land and Food Systems, University of British Columbia, Canada. The projects and the processes of learning function via a Community of Learners (comprised of university and community members) collectively exploring the terrain of food system issues in various local environments, while identifying and connecting with more regional and international issues (see Rojas 2009). The engagement of extra-university community leaders as central to academic learning processes underscores the goal and means of reorienting education to socially relevant issues. The British Columbia Community Food Security Project is one of the core program projects whereby over 1,000 second and third-year undergraduate students, several senior faculty members and graduate students, and over 30 community partners have engaged in iterative processes of learning, researching and creating positive change in food system issues throughout the province of British Columbia, Canada. The project coordinator works with the faculty and community partners to derive research scenarios and CSL opportunities that build upon the previous year's findings and that are appropriate for engagement over the course of one semester (approximately 4 months). While the CBR is conducted by teams of 5–7 students, we have established the CSL as an optional component, conducted individually in consultation with the community partners. The flexibility demonstrated in CSL attempts to reconcile the recent (as of 2007) integration of this pedagogy into the project, as well as the time and energy constraints of all involved. A majority of the students who participated in CSL indicated that the combination of community-based research and service enabled a fuller learning experience engaging head, hands and hearts. Due in part to the large numbers of students (>200/ semester) and community partners (>20) involved, the specifics for each team's community service and, to a lesser extent, community-based research are left largely up to the student teams to negotiate with their community partners. This strategy brings forth both opportunities and challenges. One option we are currently investigating is enhancement of the initial training provided for the students to undertake community-based research and community service-learning.

6. Discussion

Reflections on the processes and outcomes of university-community engagement, feedback from the community of learners, and externally administered and reviewed scores of the "National Survey of Student Engagement" demonstrate a high degree of interaction with real-world issues related to food security and sustainability. The integral role of the community and the innovative pedagogies implemented to engage and include these diverse groups enable students to grapple with real challenges facing food and environmental systems. Indications point to the development of sustainability leaders, "citizens with heightened environmental awareness, and professionals endowed with vision and tools to

define the problems, research them and find and implement solutions" (Rojas 2009).

7. Conclusion

As all education and curricula are value-laden (Posner 2004; Schubert 1986), it is essential to be conscious of the values being identified and emphasized. As educators, we must choose to stop teaching "for unsustainability" (i.e. the perpetration and perpetuation of social and ecological crises, including environmental insecurity) and transform our pedagogical perspectives to teach so that sustainability can emerge (i.e. social and ecological justice, including environmental security). In order to move beyond reproduction of our social ills, teaching for sustainability requires transformation to new ways of approaching education and life (Moore 2005). Therefore I posit that the responsibility of advanced education is to temper information with knowledge, technology with nature, economy with ecology, all within the context of specific places and communities, in our collective efforts towards environmental security.

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PERMACULTURE, A NATURAL SYSTEMS DESIGN APPROACH FOR TEACHING SUSTAINABILITY IN HIGHER EDUCATION: PACIFIC UNIVERSITY'S B-STREET PERMACULTURE PROJECT

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Abstract: Environmental security is dependent on establishing global social systems that mimic natural ecosystems and promote ecological literacy, environmental stewardship, and the equitable distribution of resources and power. The use of fossil fuels as the primary global energy source has resulted in disturbing consequences, some of which must be immediately and judiciously addressed by the global community. As leaders in the global community, institutions of higher education must abandon tradition and embrace innovation to become responsible for imparting the knowledge and skills that produce ecologically literate students. These forward-thinking institutions will embrace experiential, project-based learning practices and produce students who are environmental stewards and active citizens with a deep understanding of local ecosystems and the ways that humans can interact with them in a sustainable way. Permaculture principles have been tested and developed for over 30 years and could serve as an effective tool for teaching the concepts of sustainability in higher education. This paper describes the integration of permaculture principles into the curriculum of a small liberal arts university.

Keywords: sustainability; higher education; permaculture

1. Introduction

The expanding scale of human technology is impacting all of the earth's ecosystems. Humans are significantly altering marine and terrestrial ecosystems, biogeochemical cycles and the species that depend on these systems (Vitousek et al. 1997). These anthropogenic activities continue to damage ecological systems and we have arrived at a point in human history where little time is left to remedy

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some of the environmental problems created by these activities. A crucial step in establishing environmental security will be to address the environmental problems that have a limited time frame in which to implement solutions and will result in significant hardships to the global community if not remedied. In many instances, solutions to these large scale problems will involve a collaboration of local small-scale changes that will ultimately provide environmental security for all and prevent future environmental damage. Many of the environmental problems requiring immediate attention are related to the global dependence on fossil fuels.

The use of fossil fuels over the past 150 years has resulted in a multitude of deleterious impacts on the planet including the contamination of air, water, soil, and biota with toxic chemicals, damage to ecosystems through the extraction and transport of these materials, and the expanding production of greenhouse gases. Rising levels of greenhouse gases warrants immediate attention because of global warming and the resulting consequences for the planet in the near future. Rising levels of carbon dioxide have been attributed to fossil fuel use and has resulted in warming of the climate system (IPCC 2007a). In addition, many natural ecosystems are currently being affected by climate change, and further warming of more than 2°C relative to 1980–1999 could result in over 30% of existing species being at risk of extinction, widespread mortality of coral reefs, hundreds of millions of people experiencing water stress and negative health impacts, and increased storm and flood damage (IPCC 2007b). Yet there are additional problems created by our insatiable consumption of this ancient store of solar energy that need our immediate attention.

There are urgent concerns related to the decline in global fossil fuel production, particularly since much of the global economy is reliant on a steady and abundant supply of this form of energy. Campbell and Laherrere (1998), experts who worked in the oil industry for more than 40 years predicted that production of conventional crude oil would peak this year and then begin to decline after this, validating the basic premise of peak oil as proposed by M. King Hubbert (1949). If fossil fuel supplies do not keep up with demand there will be serious negative consequences for countries that rely on them to support basic life necessities. For example, countries whose agricultural systems rely on large energy inputs from fossil fuels will face new challenges. There will be severe impacts for developed countries like the United States whose current industrial agricultural system uses an estimated 3 cal of fossil fuel energy for the production of 1 cal of food energy, not accounting for the energy cost of processing and transportation (Horrigan et al. 2002). Feedlot beef production requires even greater inputs with 35 cal of fossil fuels being required to produce 1 cal of food energy. Declining production of crude oil will likely lead to problems with food security unless there is a shift from large-scale industrial farms to sustainable small-scale local farms that produce food best suited for a particular region using renewable energy sources. In addition, much of the large-scale environmental damage occurring to our planet can be attributed to industrial agriculture. Growing food on these large industrial farms leads to decreased biodiversity, contamination of water, soil, air, and biota through the use of synthetic chemical pesticides and fertilizers, erosion of topsoil, and consumption of water at an unsustainable rate (Horrigan et al. 2002). The

environmental damage that can be directly or indirectly attributed to fossil fuel use is significant and a rapid transition in energy use must occur given the timeline on which we have to operate in order to prevent further ecological destruction that will adversely affect life on earth.

In order to make this transition, we will have to develop sustainable systems that fundamentally operate within the confines of the daily allowance of solar energy delivered to any given area suitable for human habitation. We will have to design sustainable systems utilizing principles that are derived from the study and observation of natural ecosystems. We will have to reevaluate our relationship with the natural world and realize as Aldo Leopold stated in his land ethic "that the individual is a member of a community of interdependent parts. His instincts prompt him to compete for his place in the community, but his ethics prompt him also to co-operate" (Leopold 1949). The human habitat and niche will have to change so that sustainable energy will be utilized, and natural resources will be used more efficiently. The current dire predictions for the environmental systems of the earth should be rationale enough for making the transition toward sustainability, the first step being a significant reduction in fossil fuel use. A key step in making this transition will be education at all levels, an education that increases environmental awareness, and inspires people to live more sustainable lives.

Institutions of higher education will play an important role in this educational process, particularly since the operations of these educational communities provide a good model for the practice of sustainable design. In addition, faculty and, especially, students at colleges and universities tend to be people who are open to new knowledge and innovative pedagogy. In fact, many colleges and universities are learning that sustainability initiatives can attract potential students. However, given that these institutions are market-driven there is a tendency for them to merely pay lip-service to the concept of ecological design by implementing a few splashy initiatives that can potentially attract students looking for "green" campuses. In order for students to be educated about sustainable design, programs must be developed that are meaningful and real. Many questions remain on how to best infuse sustainability into the learning environment of colleges and universities. What is an effective way to present the concepts of sustainability to the campus community? What information currently exists on how to plan and design sustainable systems through observation of natural systems? An effective education in sustainability will model current sustainable systems, develop knowledge that leads to better sustainable practices, and provide an education that is placed-based and holistic. This kind of education can prepare students to face the challenges of declining fossil fuel supplies, climate change and the social instability that are the likely results of these events in a positive and life-affirming way.

2. Permaculture

One approach that is currently experiencing widespread growth and appeal as a tool for teaching the concepts of sustainability is permaculture, a concept and design system developed 30 years ago by Bill Mollison and David Holmgren.

Mollison and Holmgren met at the University of Tasmania where Mollison was a lecturer of environmental psychology and Holmgren was an undergraduate student in ecology. After several years of discussion and development, they co-wrote the first permaculture publication which outlined the basic premises and principals of the permaculture design system (Mollison and Holmgren 1978).

Because their early ideas were centered on constructing food-producing systems, Mollison and Holmgren coined the term "permaculture" as a combination of the two words "permanent" and "agriculture". As the concept evolved they realized that "permanent agriculture" is impossible unless social and economic patterns are included in the equation. Today, permaculture design applications include not only food-producing systems such as gardens and farms, but also housing, transportation, and energy systems. In the words of Holmgren, the permaculture designer constructs, "consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fiber and energy for provision of local needs" (Holmgren 2002). The way human communities organize themselves is fundamental to permaculture and the original concept of permanent agriculture has evolved into one of permanent culture or permaculture.

To craft a "permanent culture", permaculture designers draw on local geographic, sociologic, geologic, hydrologic, and biologic features to construct complex and interactive biosystems that include the activities of thriving human communities as design elements in the system. In contrast to large industrial agricultural systems that rely on annual monocrops, heavy inputs of fossil fuel based energy and fertilizers, and global markets, permaculture assumes local consumption and renewable energy sources. For example, one strategy for reducing the need to import energy is to install mutually beneficial perennial plant communities called guilds whose properties fulfill specific output requirements of the system. Individual guilds are nested components of the larger system and are often connected to each other through the introduction of animal species such as chickens, rabbits, and humans whose function is to recycle and redistribute the nutrients produced by the individual guilds throughout the system. In operation, this construction mimics natural ecosystems in that the input needs of the individual guilds are provided for by the outputs of other elements within the system.

The use of guilds is just one example of possible outcomes that are the result of the application of permaculture design principles. Though different authors and teachers use slightly different descriptions of these principles, perhaps the most easily assimilated definitions are given by Holmgren (2002). In his book, Holmgren distills the common thinking of permaculture practitioners into a set of twelve core organizing principles that are intended to guide the designer by focusing attention on design elements such as feedback loops, output to input connections (food/waste connections), energy use and production, productivity, niches, and diversity. In addition to the principles of design, permaculture literature gives many examples of specific techniques (such as heavy mulching, keylining, and keyhole gardens) that can be used to increase the effectiveness and productivity of the system. Rather than being a specific set of "how to" instructions however, the intent is to outline an approach that first requires the

designer to develop a deep understanding of the local social, economic, and natural conditions from which the design originates.

As a means of organizing activities, the permaculture design system focuses on certain key domains for transformation to a sustainable culture. These domains include land and nature stewardship, the built environment, tools and technology, culture and education, health and spiritual well-being, finance and economics, and land tenure and community governance (Holmgren 2002).

In addition to presenting a toolkit of adaptable principles and techniques, the permaculture designer is governed by a set of core ethics that requires the designer to balance the goal of maximizing production against practices that might create negative impacts on the social and natural elements that are part of the system. These core ethics – care for the earth, care for the people, and fair share of resources – reinforce the idea that a permanent culture must continually provide for the needs of all of its components as opposed to our current system which supports the needs of a few key elements (such as global corporations) at the expense of many others (such as non-economically important species and indigenous human communities).

These core ethics, domains, and design principles are not unique to permaculture; rather they echo the thoughts of many who are promoting a reorientation of our current culture towards practices and policies that are more sustainable. For example the environmental, social, and economic, triangle that forms the basis of understanding for many sustainable development models is directly correlated to the permaculture core ethics of earth care, people care, and fair share. One important difference between permaculture and other sustainable design systems is its emphasis on rapidly disseminating permaculture information outside academia through the intensive permaculture design certification course.

The permaculture design certification course involves 72 h of training which in normally offered through a 2–3 week course taught by an instructor that is credentialed through a 2-year apprenticeship process that includes an additional "teacher training" course. Because of the goal of propagating permaculture knowledge, the certificate training not only presents permaculture principles and opportunities for the supervised application of these principles, but also presents techniques for teaching the permaculture system to others. This self-propagating structure has generated an active decentralized global network of certified permaculturists that is continually expanding. The network communicates through journals, publications, and conferences as well as through a web-based communications system that provides an interactive forum for exchanging information, ideas and results. Currently a globally connected community of permaculture groups, projects, associations, and institutes are host to a myriad of practitioners who continue to refine design principles through application and evaluation of methodologies. As was the intent of the originators, the system has proven to be extremely adaptable over a wide range of social and environmental conditions. Countries where permaculture is widely accepted and practiced include Australia, Japan, Vietnam, Cuba, and Eastern Europe. Permaculture design applications include domestic landscapes, school gardens, large-scale market agriculture, and environmental rehabilitation and restoration sites.

Because if its world-wide acceptance as a successful model for sustainable design, and because the organized presentation of design principles are easily assimilated, the permaculture educational model is tailor-made for institutes of higher education that seek to address the current sustainability crises. Permaculture's project-based integrated systems approach makes it especially appropriate for educational institutions that emphasize service and theory to practice learning modes. The 72-h instruction period of the permaculture certification course is easily translated into a two-course series that can fulfill core requirements typically seen in many small colleges. In addition, students learning the permaculture design system will integrate academic information from across disciplines, practice critical, creative, and design thinking modes, and engage in scientific inquiry in order to complete the required projects. For students in environmental studies who are interested in outreach and education, a continued course of study is possible that includes a teacher training course and a 2 year "apprenticeship" in which students practice applying their knowledge by addressing specific problems related to bringing university operations into compliance with permaculture principles. By starting the process in their sophomore year, a student could conceivably be teaching their own permaculture sections in their senior year as part of their independent project experience.

A well-known model for this kind of service oriented project-based learning is the Adam Joseph Lewis Center at Oberlin College, which was designed as an integrated building-landscape system that functions as a core component of the environmental studies program. Under the guidance of David Orr (Director of Environmental Studies at Oberlin College), students were involved with every stage of the design and construction of the building and, now that it is finished, they continually monitor the performance of the building as part of their program of study (Orr 2006). While not a permaculture program per se, the project-based learning model closely parallels the permaculture construct though the focus is more specifically on promoting change within the American educational system rather than on the global agricultural system. In his many writings on the subject, David Orr uses the term "Ecological literacy" or "Ecoliteracy" to describe the educational goal of fostering in students a basic understanding of how ecosystems work as well as developing the ability to effectively engage in an ecologically based systems-thinking approach to problem solving (Orr 1992).

In addition, other similar approaches exist in the K-12 school system. Fritjof Capra, an author and physicist with interests in systems theory, chaos theory, and fractal algorithms, seeks to promote an ecological understanding for students in the K-12 educational system. In 1995, he co-founded the Center for Ecoliteracy in Berkeley, California, an organization that provides support for schools developing hands-on curricula around experiencing the natural world. As described by the Center for Ecoliteracy, the most effective pedagogy for achieving this goal is an integrated project-based curriculum that uses the local landscape and community as a context for learning. This direct connection to the outdoors as part of their school experience helps students develop an emotional connection to the place they live as well as a deep understanding of the complexities of the ecosystems that provide their food, water, shelter, and other daily needs. Many ecoliteracy

schools go even further by developing food-based curricula as a means to both increase ecological understanding and address other problems related to the industrialized agricultural systems such as nutrition, soil degradation, biodiversity, and energy use.

3. Pacific University's B-Street Permaculture Project

Pacific University, Forest Grove, Oregon, was founded in 1849 to educate orphans of the Oregon Trail and local Native American children. From these beginnings grew an educational institution that fosters an ethic of service that one of the founders, Sydney Harper Marsh called "right action". Pacific University is comprised of both graduate and undergraduate programs which include the Colleges of Optometry, Health Professions, Education, and Arts and Sciences. There are over 1,100 students in the graduate programs which offer degrees in Fine Arts, Education, Optometry, Occupational Therapy, Pharmacy, Physical Therapy, Physician Assistant, and Psychology. The College of Arts and Sciences provides a broad liberal arts education for over 1,100 undergraduate students, and includes 34 different majors, including Environmental Studies. Under its new president, the university is currently experiencing a period of rapid growth and expansion, which includes the addition of five new buildings, an athletic complex, and new graduate programs in the health professions. Because of the new construction and a relatively small endowment, the university budget is tuition driven and, as a result, decision making is largely influenced by the restrictions imposed by the assumption of debt to cover expansion costs. This reality has certainly influenced the implementation of sustainability initiatives at Pacific University.

Despite the budgetary restrictions described above, the university has made some strides toward becoming more sustainable in its operations. The president's cabinet has charged that all newly constructed buildings on campus be LEED certified, and thus far this charge has been upheld with four new buildings (Health Professions Building, Residence Hall, Library, and Professional Studies building) receiving a LEED certification of silver or higher. The university also hired a private consulting firm to lead an eco-charrette to help set sustainability goals for the campus infrastructure under the 2015 Master Plan (January 2006). The charrette involved faculty, staff, and students participating in lively discussions that resulted in several recommendations for incorporating sustainability goals into the university master plan. As of yet, there has not been any feedback from the university administration on whether or not any of the recommendations from the charrette would be adopted. In a separate effort, students at Pacific University encouraged the president to sign the Talloires Declaration, which he did in February 2007. Signing the declaration commits Pacific University to a ten point action plan set forth by the Association of University Leaders for a Sustainable Future. Thus far the administration has done little to help stimulate and promote the implementation of action items listed in the declaration. Though efforts have been made towards adopting the action plan, progress has been slow because of

the aforementioned expansion the university is undergoing in other areas. A recent effort to address the goals of the Declaration was initiated by Environmental Studies faculty and supported by the university Provost which resulted in the creation of a University Sustainability Committee made up of students, staff, and faculty representatives. Additionally, there does appear to be support from faculty and students for the implementation of university-wide sustainability goals through grass-roots initiatives taken on by faculty, staff, and students. One of these grass-roots initiatives is the B-Street Permaculture Project.

The B-Street Permaculture Project was the result of a faculty sabbatical project, and was initiated as a way to jump-start a conversation about how the university could address issues related to sustainability such as environmental security, food security and energy security in an interdisciplinary and systemic way. Through financial support from Pacific University's Humanitarian Center, Terry O'Day received training and certification in permaculture, and began developing the site utilizing permaculture design principles.

The project site is located on a publicly owned property less than a mile from the Pacific University campus in Forest Grove, near the intersection of Gales Creek and B-Street. The 3-acre site is situated in a flood plain and has a 1 acre field that is used as a research/market gardening area. Other site features include an orchard and a small house. Early site development involved removal of invasive plant species and planting 1,200 native shrubs along the riparian zone in order to provide shade, stabilize the creek bed, and improve habitat for aquatic species. In addition, housing was built for small animals (goats, chickens, and rabbits) that were selected for their ability to be integrated into the permaculture design that was being developed for the site which included their potential to attract visitors, provide marketable food products, provide waste products as a source of fertilizer, remove weeds and invasive species, and educate visitors on the use of animal products. After 3 years of operation, the site now employs a full-time staff member that works under the supervision of the university facilities director. Additionally, the project's strategic plan calls for a new staff member to focus on outreach, education, and curriculum development support for faculty who wish to incorporate sustainability concepts and site-based projects into their courses.

The site's mission is based on the permaculture principles of care for the earth, care for the people, and fair share of resources, as applied through systems thinking design methods. Permaculture at its foundation is a systems approach to designing environments that support human activities in a sustainable way. As such, it is an ideal vehicle for introducing the concept of ecologically-related systems thinking processes into the curriculum of a liberal arts college. Systems thinking requires a broad interdisciplinary understanding of cultural and environmental structures; connecting the permaculture project to the study of the liberal arts at Pacific University allows students and faculty from every discipline to contribute and combine their efforts in a synergistic way.

Though the individuals who were directly involved with the project had a clear understanding of the origins, concepts and goals of the permaculture design process, the main barrier to integrating the concept into classrooms across the

college was the general lack of information among administration, faculty, staff, and students about the place-based, service oriented pedagogy that is common to the educational approaches whose goals are to develop sustainable cultural practices in their students. As a result, one of the first objectives of the project initiators was to disseminate information about the terminology and concepts that they were seeking to promote.

One simple strategy that was used to generate discussion about the mission and values of the project was to choose a name that would attract attention, force inquiry, and even generate controversy. Though the word "permaculture" is fast gaining recognition in many parts of the world, in the US and, especially, in academia, there are few individuals who recognize the term and even fewer who understand what it means. For those who have had some exposure to the term, it often brings to mind activist, and even anarchist associations. Though many who refer to the project call it a farm, founders of the project are quick to point out that the word "farm" as currently applied to the industrial agriculture model, has many associations that are not consistent with permaculture goals and values. Because of the name choice, individuals associated with the project were frequently called upon to explain and even defend the project. The lively conversations that ensued from this choice of name quickly raised the level of general understanding about ecological design principles as well as the education methods behind the concept.

As a grass-roots initiative, the main focus for the project in its early stages was to develop a community of interested and active individuals who were connected to ideologically aligned programs that could provide some means of administrative or budgetary support as well as provide programming or develop courses that would direct students onto the site. As described below, these agencies were instrumental in generating the staff, student, and faculty interest and activity needed to bring the project to a point of critical mass where it began to be self-generating. The main structural entities that provided the support needed were the Humanitarian Center, the Environmental Studies Program, and the Career Development Center. Each of these entities provided support according to its function within the college.

With 18 years of experience in connecting campus to community through the service learning program, the Humanitarian center provided connections to many of our project partners as well as financial support and expertise in structuring the project in a way that provided maximum benefit to the students involved in service learning activities. The director of the Humanitarian Center has a strong interest and knowledge base in social justice, indigenous peoples, and place-based sustainable practices.

Environmental Studies provided a home for the project, contributed part of its budget, gave it administrative support, and began developing a program based on permaculture principles as a means to introduce students to systems approach of addressing sustainability issues utilizing the site as a learning laboratory. Environmental Studies is undergoing a transformation from a program that was primarily focused on environmental science to one that is more holistic and views sustainability as a core principle that guides the development of new curricula. The

development of the B-Street site has been instrumental in facilitating this transformation. Students in the program use the site for research, class, and senior projects as well as helping to develop the infrastructure of the site as part of the service learning requirement to many of their classes.

The Career Development Center connects students to work-study and internship opportunities related to their career goals. The center supports learning that connects theory to practice within a supportive environment. The B-Street Permaculture Project provides an opportunity for students across disciplines to work in one of four categories: organizational development, site development and management, finance and marketing, and outreach and education. Career services provides administrative support by providing a budget for work-study employees and posting job listings. The support from these university organizations has provided the essential resources needed to create a site that serves as a focal point for sustainability initiatives and as a leaning laboratory for sustainable design.

In its early stages, project developers worked with interested faculty to provide information and background support for assignments in a variety of courses and departments such as Environmental Chemistry, Environmental Literature, Education, and Anthropology. As the project developed, however, some faculty began designing entire courses around specific elements of the project mission and goals. For example, an ecological art course was taught at the site. Course content included an overview of permaculture concepts and principles, and student projects included the opportunity to install ecological and environmental artwork on the site grounds. As trained systems thinkers who are often agents of culture change, artists can synthesize and present information to the general population that is accessible in ways that written communications are not. For example, artist Betsy Damon creates large-scale art parks along polluted waterways or in areas of heavy storm water run-off that feature ponds, filters, and sculptural flow forms that visibly clean the water as it passes through the park. By interacting with the park, visitors can begin to appreciate the preciousness of this finite resource. Some of the artworks installed at B-Street echo Damon's work by alerting visitors to the fragile state of the local creek that is home to an endangered species of fish. Other courses under development are agroecology, renewable energy, natural building, and edible forest gardening.

To provide a foundation and centerpiece for course offerings taking place at the site, the Environmental Studies program began offering a two-semester permaculture certification course in 2007. This course is currently being taught by permaculture designer, practitioner, and author Toby Hemenway. Students who complete both semesters will receive their Permaculture Certification from the Permaculture Institute (USA). The first semester course (Fall 2007) had 34 registered participants which largely consisted of undergraduate students from a variety of academic disciplines. Other participants included two university staff employees, the university facilities engineer in charge of landscape operations, the B- Street site manager, a biology faculty member, and a teacher from a local K-12 environmental charter school. In keeping with the permaculture goal of rapid

dissemination, these non-traditional participants will be able to take the permaculture concepts they learn to their respective organizations and apply this knowledge where appropriate.

In the near future, the permaculture design course will be co-taught by two Pacific University faculty members who are currently going through the permaculture teacher certification process. Because of their familiarity with university operations and their connections to faculty staff and students, these "in-house" permaculture instructors will be in the position to act as advocates, coordinators and informants for students, faculty, and staff members working to incorporate sustainability concepts into university operations and college curricula.

As they reach the upper levels in their coursework, students begin to develop independent projects under the supervision of a faculty supervisor. Research projects allow students to apply the information they learn in the classroom to real-world experiences in a supportive and engaging environment. Since upper level students specifically choose to work at B-Street for their independent projects, they have a genuine interest in the site mission and are motivated to do excellent work because they can see firsthand the benefit the site derives from their efforts. In addition, these projects often become the centerpiece of student resumes and it helps them form connections that can ease the transition to life after college. Projects have been quite diverse and have involved students from a variety of academic disciplines including art, biology, business, media arts, and environmental studies. Some of these student projects are described below.

One student focused on implementing and institutionalizing a kitchen composting system. This project led to an invitation to attend a national conference for young leaders. In addition, the student was interviewed by a news reporter for a story about sustainability initiatives at Pacific University. In another project, a student designed a mini-website that included interviews with students and descriptions of specific project initiatives. The final result of this project was embedded into the official B-Street Permaculture Project website. Another student, doing a senior research project on the local watershed, was part of a grant-writing team that developed a proposal for a $25,000 grant to install a floodwater mitigation and rainwater harvesting system at the site. Yet another student worked with local non-profit organizations to install a children's garden at the site.

Activities such as these allow students to apply the information they learn in the classroom to real-world experiences in a supportive and engaging environment. Though good grades are helpful in finding employment after college, these theory-to-practice projects give students the practical experience they need to be successful in their chosen fields. These projects are also an essential component in the development of a valuable community resource whose purpose is to provide information on and demonstration of sustainable practices that are applicable to both individual households and city operations.

In addition to supporting classroom activities, the project offers an important interface opportunity between Pacific University and the Forest Grove community and is a way to disseminate permaculture information to the town of Forest Grove. Events such as the Earth Day picnic celebration draw local farmers, Pacific University students, and town residents to a gathering where they share their

interest and commitment to the site's mission. Local and regional garden tours often feature the project and give students an opportunity to talk with visitors about the project's mission and their role in supporting it. By growing food for the farmer's market, students and community members see firsthand the ways that altering the way we grow and market our food can strengthen community bonds, support the environment, and bring economic prosperity to our local community. Local schools use the site as a field trip destination, and environmentally-oriented bike tours spend a few hours working at the site in exchange for a place to camp for the night. As the site develops, we expect even more opportunities for interaction with students and community members through, permaculture, gardening, food preservation, and natural building workshops.

4. Conclusion

All College and University students will inherit a planet that is much different from the one that students faced in past years. These graduates of the twenty-first century will have to cope with changing climatic conditions, declining fossil fuel production, compromised ecosystems and all the economic and social hardships that will result from these factors. In light of these circumstances, much of the education that we currently provide for college and university students is antiquated. It may have been an appropriate preparation for students facing life in an age of expansion and inexpensive energy, but we now need a new educational paradigm to equip students with the skills, tools, and knowledge that will enable them to reorganize society into a collection of interconnected communities working within the confines of ecological design.

As student demand for a new approach rises, colleges and universities will have to provide a new and innovative core education for all students that include subject areas in renewable energy, natural building, ecological economics, sustainable agriculture, water management, natural history, thermodynamics, and social equality. There are few tried and tested models on how to develop a curriculum in higher education that focuses on sustainable design. The permaculture design system may be an appropriate model for use in higher education because it is well-established and has been practiced and refined for over 30 years, resulting in a diverse network of practitioners in both rich and poor countries on all continents who have successfully applied this system to wide variety of situations.

Establishing the B-Street Permaculture Project at Pacific University has provided a learning laboratory that enables the university community to study sustainable systems utilizing permaculture design concepts. Connecting the permaculture project to the study of the liberal arts at Pacific University has allowed students and faculty from every discipline to contribute and combine their efforts in a synergistic way and has paved the path for an integrated place-based curriculum that uses the local landscape and community as a context for learning. To prepare students for their lives after graduation, colleges and universities will need the vision to create a learning environment that promotes collaboration, innovation, and initiative. No longer will these institutions produce students who contribute to

environmental degradation and social stratification. Instead, they will produce students who are good ecological citizens and well-equipped to usher in a new era of human evolution.

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ADDRESSING THE USE OF NON-TRADITIONAL METHODS OF ENVIRONMENTAL EDUCATION: ACHIEVING THE GREATEST ENVIRONMENTAL AND EDUCATIONAL BENEFIT FOR THE EUROPEAN REGION

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Abstract: The use of non-traditional methods of environmental education can greatly support attempts to foster awareness on environmental issues on the one hand and catalyze personal action towards sustainable development on the other. Yet, there are some issues that need to be considered in order to allow non-traditional methods to be implemented. This paper will review some of these issues and provide some examples of successful approaches to raise awareness about environmental issues by means of non-traditional methods.

Keywords: environmental education; sustainable development; non-traditional methods; student involvement

1. A Review of the State of Affairs in Relation to Environmental Education and Education for Sustainable Development

Sustainability is today one of the most widely used words in the scientific field as a whole and in the environmental sciences in particular. The evolution of such a concept has been progressing steadily over the past three decades (Leal Filho 2000; Leal Filho et al. in press).

A key question that is posed over and over again by people all over the world – is *what does sustainable development really mean*? Some examples, selected and presented below, illustrate a variety of meanings, such as:

- The systematic, long-term use of natural resources – as defined in the Brundtland Report – so that these are available for future generations (here referring to country and local policies)

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- The modality of development that enables countries to progress, economically and socially, without destroying their environmental resources (here referring to country/national policies)
- The type of development which is socially just, ethically acceptable, morally fair and economically sound (here referring to the social ramifications of development)
- The type of development where environmental indicators are as important as economic indicators (here referring to the close links development bears with economic growth)

Table 1 outlines some factors which influence attitudes towards sustainability and describe their implications. An understanding of such factors is important in order to allow the integration of sustainability concepts and ideas in the framework of both policies and school/university curricula.

TABLE 1. Some factors which influence attitudes towards sustainability (Modified from Leal Filho 2000).

Knowledge	Information on the meaning of sustainability and its implications
Background	The nature of his/her training often influences an individual's degree of receptivity in relation to sustainability
Experience	Previous experience with environmental and social affairs facilitates understanding on the role of sustainability
Perception	The integrated view of environmental, political and economic elements enables a broader perception of sustainability
Values	Differing from the previous ones due to its high degree of complexity, an individual's values often determine whether his/her attitudes are favourable or otherwise
Context	Sustainability is not only related to ecological components per se, but also entails items such as economics, politics and social matters. However, links with the latter are often ignored by schools and universities

In the international debate on sustainability, emphasis needs also to be given to environmental education, which is currently being referred to as "education for sustainable development" (ESD). The publication of the *International Strategy for Action in the Field of Environmental Education and Training for the 1990s* (UNESCO-UNEP 1988) was a concrete step forward. In addition, Agenda 21 (UN 1992) as a whole and Chapter 36 (Promoting education, public awareness and training) in particular and its subsequent endorsement by over 100 governments, further reiterates the value the international community affords – at least in principle – to sustainability and to education for sustainable development.

Similar to what happened with the term "sustainable development", education for sustainable development has been proposed in various formats (Leal Filho and Pace 2006), i.e. Environmental Education (EE) (UNESCO 1980); Earth Education

(van Matre 1990); Environmental and Development Education (EDE) (UNCED 1992); Environmental Education for Sustainability (EEfS) (Tilbury 1995); Education for Sustainability (EfS) (Huckle and Sterling 1996); Education for a Sustainable Future (ESF) (UNESCO 1997); Education as Sustainability (EaS) (Foster 2001); Sustainable Development Education (SDE) (Smyth 2002); etc.

A review of the principles of environmental education – as proposed by the Tbilisi 1977 Conference (UNESCO 1980) and subsequently confirmed at the Moscow 1987 Congress (UNEP 1987), the Thessaloniki 1997 Conference (Scoullos 1998) and re-proposed as Education for Sustainable Development (UNESCO 2005), shows that the use of non-traditional methods can be of great assistance in raising awareness about and fostering action in respect of environmental issues.

Indeed, the primary goal of environmental education is to enhance students' perceptions by involving them in situations beyond the classroom and into the real world. To do this it is important that appropriate methods are used (Tal 2005) in order to allow student engagement and ensuring the quality of the activities being undertaken.

2. Examples of Non-traditional Initiatives

Due to limitations in resources, time or even lack of training of teachers (or a combination of both), many opportunities for non-traditional student involvement in environmental education are primarily limited to piggybacking on activities run by private organizations. But it does not have to be like this. In addition to exotic experiences in the sea, in rivers or in far-away places, which are not within reach of ordinary schools, there are real possibilities of using non-traditional – some would say informal or innovative-methods even in the context of the normal school setting. A framework to use non-traditional initiatives is seen in Figure 1.

In order to allow a better understanding of the possibilities available, some examples of initiatives, as outlined by Leal Filho et al. (in press), are herewith provided.

The first example refers to a methods titled "***Using Green Technology***". Students are presented with a problem to create a piece of furniture made entirely from recycled and "unorthodox" items. Working in small teams, students must incorporate at least three different materials to make their "new" piece of furniture. Since students are not allowed to purchase materials, their solution must be made entirely from scrounged materials. As a result of this problem, students can create a wide assortment of furniture pieces from a variety of recycled items such as tire rims, old tarps, foam insulation, and broken products. For example, one team may make a fold-up bed from old closet doors. This activity is likely to receive much support from the school's administration and positive public relations in local newspapers.

Suitable topic	Themes or topics to be carefully chosen, set of issues to be considered are identified
	↓
Communicate to whom	Groups to be reached, ages of the recipients of the information, other possible stakeholders
	↓
How to communicate (approaches used)	Talks, discussions, interviews, use of the media, briefings, reports
	↓
Handling information/data	Collecting economic data, ecological indicators; calculating losses deriving from no action
	↓
Raising interest	Bringing the global to the local level, relating to one´s responsibility, showing different contexts
	↓
Motivating action	Emphasising the need for personal action, showing the consequences of inertia, illustrating – concretely – what can be done

Figure 1. A framework to use non-traditional initiatives (Own visualization).

Through this activity, students begin to ask a lot of good questions about design and recycling, as well as technical questions about how to combine the materials using tools and machines. They learn to become more independent because of the open-ended nature of the problem and the need for them to show initiative in identifying and locating the materials that they need to solve the problem. Since they work in small groups, they must also develop teamwork skills in order to have a successful solution to the problem. Furthermore, this activity helps them to understand and interact with technology in their world and see that they can be part of the solution to the recycling problem by being creative, technological problem-solvers (Martin and Martin 2006).

A second example of activity is titled "***Exploring Alternative Energy Production***". The purpose of this activity is to explore how society will meet its future energy needs. The course may use textbooks, articles, and a series of experiments to explain a variety of energy related technologies.

The goal is to provide students with the opportunity to explore energy production and distribution systems in order to develop an appreciation for the social, economic, and environmental impacts of these technologies. Students may work with energy conversion systems that are environmentally friendly and renewable in an effort to inform themselves on potential solutions that can meet our future

energy needs. In the process, students identify academic strengths and weaknesses that relate to the design professions. The course may provide each student with the knowledge and skills necessary to use technology as a creative tool.

A third example is about "***Energy Transformation Devices***". Students are asked to design an energy transformation device that is contained within 2' x 2' footprint and created entirely from recycled materials. The device must incorporate all six simple machines to transfer motion from the input to the output. The unique aspect of this device, however, is that each team's design must integrate with the next team's design so that all the energy transformation devices can be combined into one large energy transformation device (transferring energy from the first device to the last device in consecutive order). This engineering design activity is adapted from one developed and promoted by US-based Project Lead the Way and known as the SMET device (using Science, Math, Engineering, and Technology to create a Simple Machine Energy Transformation Device).

Students' designs must be developed on paper prior to beginning construction, with the design scanned into the computer and serving as the "legally binding design document". Students are penalized if they vary the design without first filing an engineering design change notice. Throughout this design activity, students must keep a journal and document their design process, including all necessary calculations pertaining to the problem (e.g. force, weight, distance). Students are encouraged to design and build appealing solutions (e.g. no tape allowed) that solve the problem in the most creative manner. They mostly use hand tools, but they have access to other special tools to enhance their design (e.g. a laser cutter to engrave or cut parts).

Through this activity, students learn about energy transformations, kinetic and potential energy, mechanisms, and important items such as environmental ethics (Schleicher 1996) and more. This is an exciting challenge for students and one that helps them begin to value the importance of planning ahead and relying upon scientific and mathematical information or research to inform design solutions. Students get a sense of how products are designed in the real world and the importance of accuracy in transforming designs from paper to final product. Students often refer to this Rube Goldberg influenced idea as the "coolest project!" (Martin and Martin 2006).

2.1 CASE STUDY: THE BALTIC UNIVERSITY PROGRAMME

A further, slightly more demanding example of non-traditional environmental education is offered by the Baltic University Programme (BUP), a network of more than 180 universities and other institutes of higher learning throughout the Baltic Sea region. Due to its scope and focus, it will be used as an additional case study in this paper.

The Baltic University Programme was initiated by Uppsala University in 1991. It has its roots in the major changes in the Baltic sea region at the end of the Cold War. The global efforts to promote sustainable development started in the same period, with the World Summit for Environment and Development in Rio in 1992.

Today the Programme has developed into one of the larger university networks in the world. The participating universities cooperate in areas of common interest for the whole region – a sustainable regional development.

The network is coordinated by the Baltic University Programme Secretariat, a part of Uppsala Centre for Sustainable Development (UppsalaCSD) at Uppsala University, Sweden. The Programme focuses on questions of sustainable development, environmental protection, and democracy in the Baltic Sea region. The aim is to support the key role that universities play in a democratic, peaceful and sustainable development. This is achieved by developing university courses, and by participation in projects in cooperation with authorities, municipalities and others. The chosen subjects are of common concern for the entire region, and the international cooperation is of key importance.

A particular BUP project used to link sustainability, environmental protection and interdisciplinary learning by means of an outdoor learning approach is the SAIL (Sustainability in Applied International Learning) project, a sailing cruise across the Baltic Sea Region (BSR). The BSR is a semi-enclosed sea alleged to be the largest body of brackish water in the world. About 85 million people live in the Baltic drainage basin, hereof 29 million within 50 km of the coast. The environmental situation in the Baltic Sea has drastically changed over recent decades. Human activities both on the sea and throughout its catchment area are placing rapidly increasing pressure on marine ecosystems.

Since 1998, a group of students from across the Baltic (Figure 2) has taken part in a cruise organized by the BUP across the Baltic Sea each summer. The Summer Cruise on the Baltic Sea takes place on board the sailing ships Fryderyk Chopin or Pagoria – both Polish sailing ships. On each cruise there are about 30–35 students and 8–10 teachers from many countries.

An active participation in the educations on board is a requirement. It is also required that the student should participate as a sailor in sailing the ship and by being a member in the watch duties on the ship around the clock. Students are divided into three shifts and obliged to share all duties such as sailing and navigating the ship or cleaning and cooking. They are warned that they will be responsible for all work on board during the 4-h watch, day and night. All participants will receive sailors' certificates for this duty.

The education consists of workshops, seminars and group discussions during 17 days at sea on board a tall ship. In addition to the normal chores on the ship, lectures are held on board by the team of professors who come from countries as varied as Germany, Sweden, Russia or Poland. The lecturers offer advanced international, interdisciplinary insights on sustainable development in the Baltic Sea region.

In addition, students have to perform scientific group assignments and are also required to keep personal journals for the duration of the cruise. Some time for studies and reflection is also available. Students are encouraged to write whatever they want and journals are only collected for a cursory check at the end of the course, without any of the content being read. If they want to, students can use the journal as the basis for a creative writing piece that may be submitted as a required part of their grade once they return home.

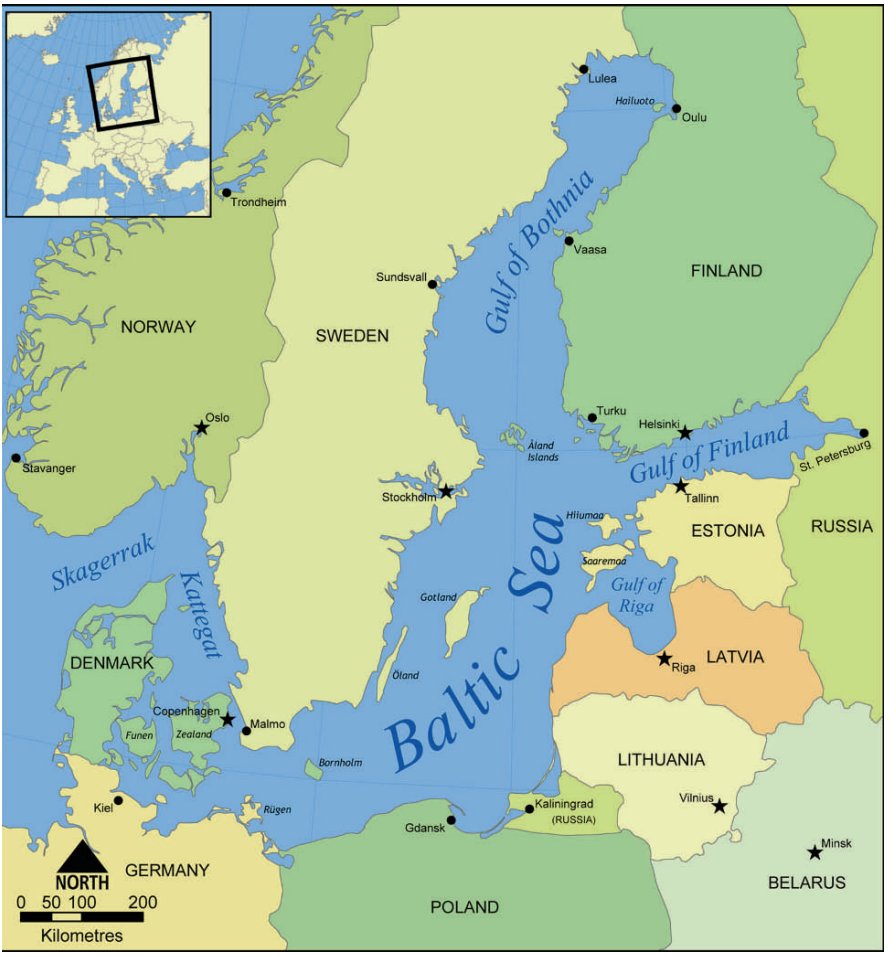

Figure 2. The Baltic Sea Region (Norman Einstein/Wikipedia)

Figure 3. The sailing ship STS Fryderyk Chopin (http://www.balticuniv.uu.se, 30 March 2008).

Figure 3 shows the ship and Figure 4 illustrates the route it took in the 2007 summer cruise. A student from a recent trip stated:

"We started our trip on September 12 at 9.30 AM from Swinoujscie (Poland). A merciless storm attacked us even before the night started. There are not appropriate words to describe the feeling of sea-sickness. Every, even the tiniest movement is mission impossible – to get up from your bed, to dress, to bend down and lace your shoes. You cannot think about eating, every smell makes you feel dizzy. It is hardly possible to wash yourself, not to mention other important activities such as lectures. And your only salvation is the deck – the fresh, cold wind and the invigorating drops of salt water".

The ship makes some stops during the cruise, in the context of which students can go ashore and experience the society and the life in a different country. The same student reported:

"We entered Liepaja port (a port in Latvia) on the late afternoon of September 19, and spent some time waiting for the customs officers to grant us entrance to the Latvian soil. But this time was not wasted – we climbed the masts and cleaned the deck in order to make the ship look pretty. In Liepaja we visited the city itself, had another portion of lectures – this time at the Liepaja Academy of Pedagogy. After that we were guests of the Mayor in the City Hall. We had a wonderful time in Liepaja – academic activities during the day, and many leisure events in the evenings, but nobody expected that... Neptune was already waiting for us!"

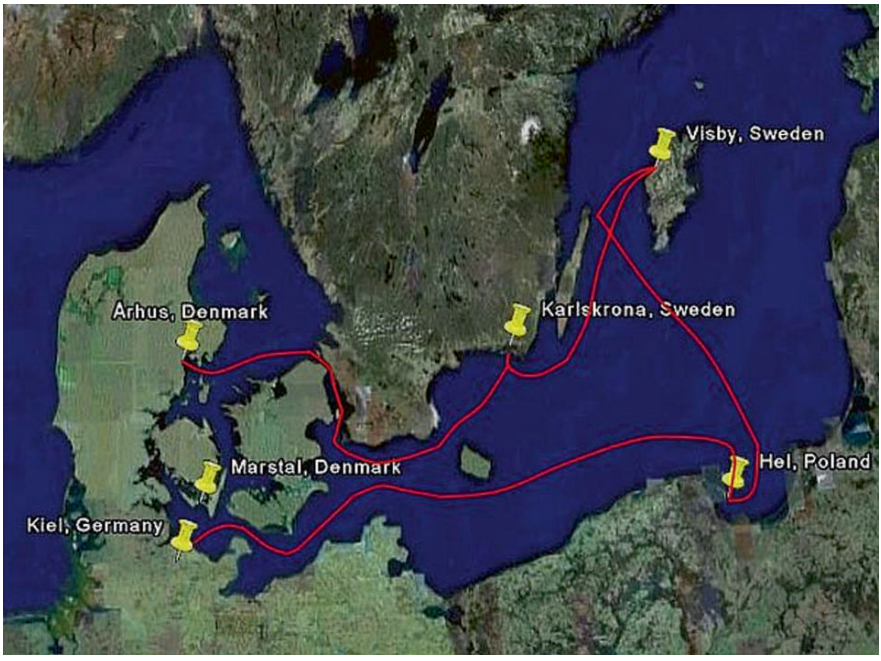

Figure 4. The route of the ship in the 2007 tour (http://www.balticuniv.uu.se, 30 March 2008).

And a final statement from one student summarizes the overall learning experience with the following words:

"The problems we had made us realize what that Baltic Sea is and why it is worth protecting. No other experience could give us this knowledge so clearly".

3. Conclusions

As outlined in this paper, there are some good examples of the use of non-traditional methods that can both raise awareness about environmental issues in the European region as well as catalyze action. Some can be used in the classroom and some, such as the cruise trip, can take place outdoors. University programmes such as the Baltic University Programme can assist in the implementation of non-traditional methods by providing opportunities and settings where learning can take place in an interesting and practical way. The 13 national BUP centres distribute information on sustainability courses and develop national and international programme activities using the Baltic Sea region as a focal point, but at the same time ensuring a broad awareness on environmental and sustainable development issues is built.Non-traditional methods offer experiences that are invaluable for truly engaging students in the excitement of science and necessary for adequately preparing these students for their future careers and as citizens. Given that most schools offer physical locations with an array of possibilities for activities, it is not impossible to be creative and at the same time keep within the limits of school budgets.

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TEACHING THE ENVIRONMENT AS A BRIDGE TO PEACE AND SECURITY IN THE MIDDLE EAST: THE PEDAGOGIC APPROACH OF THE ARAVA INSTITUTE FOR ENVIRONMENTAL STUDIES

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Abstract: Many environmental problems in the Middle East are essentially transboundary and thus a regional and cooperative approach is required to address them. Environmental education is a key element in this approach. The Arava Institute for Environmental Studies has developed a unique pedagogical approach that combines the study of the environment with cooperation and peace-building. The intense and long-term immersion of Israelis, Palestinians, Jordanians and international students and researchers in the Institute's academic and research programs provides a sound and secure framework on which to build strong and confident environmental leaders and sustainable environmental programs.

Keywords: environment; education; Arava Institute; cooperation; transboundary; Middle East

1. Introduction

Since its establishment in 1948, the state of Israel has been facing an unending political, security, economical, religious and social struggle. Adequate education, including higher education, serves as a major tool in the ongoing efforts for attaining normal living conditions, enabling progress and development based on modern standards and criteria.

Consequently, one of Israel's, and the Middle East's, greatest challenges over the last few decades is ensuring environmental security. Most of the region's (Israel, the Palestinian Authority and Jordan) natural resources, particularly water,

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are already heavily exploited (Jabbra and Jabbra 1997). An additional complication is that most of these resources are also transboundary requiring the implementation of joint management programs in a political fractious region. An essential component to the sustainable management of these scarce resources is education (Jabbra and Jabbra 1997; Lowi 2001). The study of the environment is now a cornerstone at most universities in North America and Europe, yet it has only been recently introduced in the Middle East. To date there is only one established environmental studies school at an Israeli university, the Porter School for Environmental Studies at Tel Aviv University. At most universities in Israel, the environment is studied as a series of courses normally falling under the department of Geography. There are no universities in Israel that offer a full undergraduate or graduate degree in environmental studies; Tel Aviv University will be the first to do so through the Porter School. In Jordan and the Palestinian Authority, the study of the environment is normally limited within the realm of the sciences and engineering. In all three countries there is little being offered in terms of a multi-disciplinary approach to the study of the environment. This approach is now de facto in most environmental studies programs in North America and Europe (Zoller 1990).

Even though environmental education in institutions of higher learning in the Middle East is a nascent phenomenon, environmental awareness among the public, within government and in educational institutions is growing, although much work still needs to be done in the field of environmental literacy and education. For example, Negev et al. indicated that the objective of achieving environmental literacy in terms of environmental education in Israel's public schools has not yet been achieved (2008). Moreover, it is the non-governmental sector that has been filling the gap in environmental education, especially in higher education. The number of environmental NGO's throughout the region has been growing ever since the mid 1990s. One such NGO, whose founding agenda is that environmental education is a key to peace-building and cooperation in the Middle East is the Arava Institute for Environmental Studies (AIES).

2. The Arava Institute for Environmental Studies

The Arava Institute for Environmental Studies (AIES), situated on Kibbutz Ketura (a communal agricultural settlement) at the Southern tip of Israel, is a unique higher education institution aiming at generating a new core of regional leaders working for the advancement of a robust peace via sustainable and cooperative management of the region's natural resources.

For over 10 years the institute has been teaching environmental studies to university students (both undergraduate and graduate) from all over the Middle East and the world. The unique approach of the Institute is to teach the environment, which we all share, as a bridge to cooperation and peace building in the Middle East. The pedagogic approach is multidisciplinary, and all courses are accredited via Ben-Gurion University of the Negev.

Students come to the Arava Institute from Israel, Jordan, and the Palestinian Authority, as well as elsewhere in the world. The Institute's focus is on the immediate Middle East Region of these three countries. Some students participate in a 2-year master's program under the auspices of Ben Gurion University of the Negev while others take undergraduate courses. International students often come as part of their undergraduate studies for a semester or a year "abroad". All of the courses and programs are taught in English.

The basic aspect of the program is the high-level university coursework in environmental issues, using the local desert environment as an outdoor classroom. The program offers courses in an interdisciplinary framework that includes the sciences, social sciences and socio-cultural studies as it pertains to environmental studies. Some of the courses offered include: Water Management, Comparative Environmental Law, Environmental Economics, Chemistry and Physics for the Environment, Human Aspects of Environmental Science, Environmental Ethics, Sustainable Development, Environmental Policy, Ecology, Environmental Science, Sustainable Agriculture, Environmental Education, etc.

The Institute stays current with the leading environmental issues of the day by offering pertinent courses in energy, and renewable resources and climate change.

AIES students also pursue independent research in which they are guided and mentored by professionals in the field they choose. Very often this research can be incorporated into a future graduate research project or may link into an existing project in the research department at the Arava Institute. However, all students review research methodology, prepare research questions, and conduct and present their work at an Institute symposium.

Within the framework of the Arava Institute, all students participate in fieldtrips that take them out of the realm of theoretical studies and deepen their connections to regional environmental issues and the efforts to prevent and reduce these problems. These fieldtrips are adapted each semester to the current situation; students travel within Israel, in Jordan and, situation permitting, to areas in the Palestinian Authority. The content of the trips is designed to emphasize course topics.

The Arava Institute is, however, much more than just another institute of higher learning – it is a place of learning infused with values such that students get a loud, clear message that they are expected to be themselves and to learn about others, and that they will make the world a better place. Students participate in a required program, the Peace building and Environmental Leadership Seminar (PELS). PELS is a mandatory semester-long program that deals specifically with the Israeli-Arab conflict, albeit within an environmental context. The PELS Coordinator works closely with other Arab-Israeli coexistence organizations, such as the Israel Palestine Center for Research and Information (IPCRI), and projects in the region in order to ensure the content of the program is constantly updated and is sensitive to the diversity of the student body. This unique aspect of the education program at the Institute reflects the guiding vision of the Institute that "the environment knows no borders" and that solving the region's environmental problems requires regional cooperation.

PELS is an excellent forum for instituting this vision and for mitigating tension arising from differences in political or religious beliefs, as well as misunderstandings arising from cultural and social interactions. With each year since its implementation, evaluations from the program have highlighted the positive effect PELS has had on students' perceptions of each other. The PELS is a safe and facilitated forum for discussions that encourage self-expression while building mutual respect across the religious, political and social differences that are strong elements of each student's identity. Skills acquired by participants during the program are indispensable throughout their professional careers as they pursue solutions to environmental conflicts after they graduate from the Arava Institute. Throughout PELS, students also employ and build on their competency as leaders in order to face the challenges presented by the search for environmental justice in the Middle East. Students are trained to apply the principles of PELS to their future professions through exercises, discussions and lectures.

The Arava Institute invests in the social capital of its students, faculty and staff in building the necessary personal and academic relationships for long-term cooperation in the field of environment. Unlike many of the Israel/Palestinian coexistence groups, which meet only for a few days or at most a few weeks at a time, the Arava Institute brings students together for a minimum of a semester, while many stay for a year or 2 years. Because at the Institute, students spend *so* much time together, real long-term relationships and ongoing contact continue after they finish the program. The Arava Institute aims high – the target is that the future Environmental Ministers for Israel, the Palestinian Authority, and Jordan will all be graduates of the Arava Institute programs.

Most of the graduates of the Arava Institute go on to work or volunteer in the environmental field. The Institute's Alumni projects department works to nurture alumni as they move on to greater positions of influence and power. Together the alumni have formed the Arava Peace & Environmental Network (APEN) to consolidate and complement the efforts of alumni in the fields of regional cooperation and environmental sustainability.

One area in which those ambitions are realized is the Arava Institute's Research Program. Similar to the pedagogic vision of the Institute, the research program undertakes high level and cutting-edge research also based on cooperation in transboundary environmental issues. Graduating alumni from the academic program have taken up various positions with the different research teams in cooperative trans-boundary environmental research from Israel, the Palestinian Authority and Jordan. Projects tend to be interdisciplinary in nature involving social and natural sciences that converge on a range of environmental issues, including biodiversity, sustainable agriculture, environmental education, air pollution, stream restoration and the future of the Dead Sea basin.

3. Indicators of Success

To date, over 500 students have attended the Arava Program, with over 50% female participation. A core indicator of success is the intimate nature of the program. Semesters normally consist of approximately 30–40 students with an equal number of Jewish, Arab and international students. Such a framework assists in establishing and maintaining the close personal ties that occur between the students and continue when they become alumni and professionals. Nonetheless, student enrollment is somewhat dependent on the capricious nature of the region's political environment. During the second intifada (Palestinian uprising) of 2000–2002 student enrollment decreased quite dramatically. In the current period of calm, student numbers have increased and predictions are that future semesters will enroll up to 60 students (Figure 1).

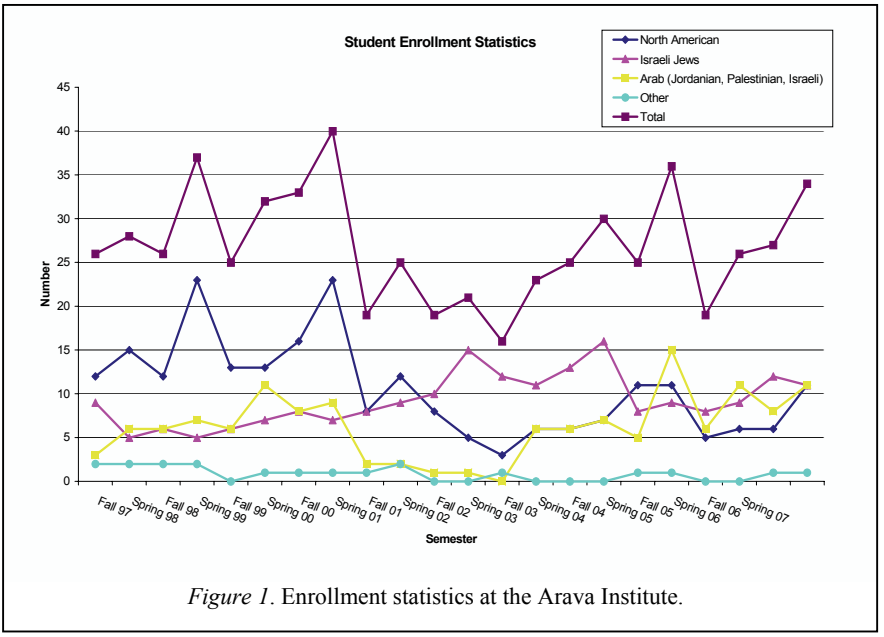

Figure 1. Enrollment statistics at the Arava Institute.

Figure 2 indicates the nationality (in percentages) of students who have attended the institute since its founding in 1996. Approximately two thirds of the students represent the Middle East.

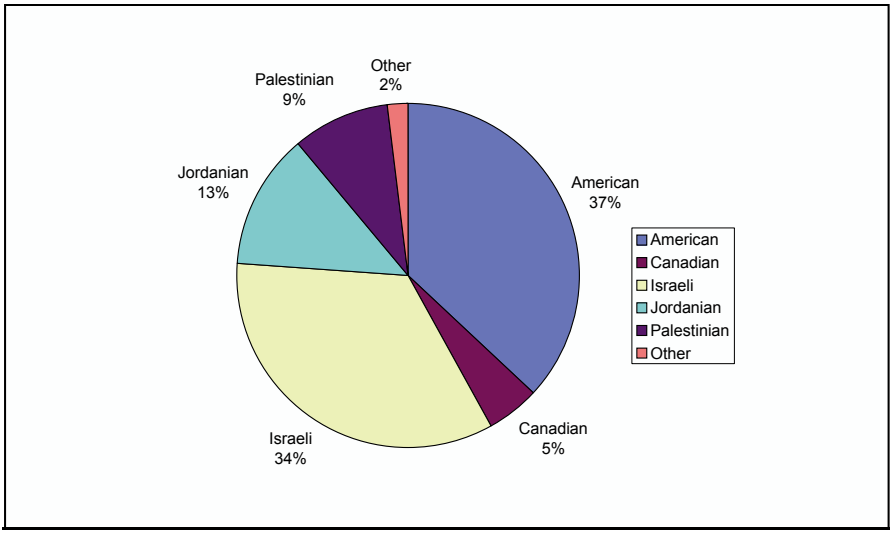

Figure 2. Nationality of Arava Institute students (in percentages). Total number of students = 432 from 1996–2007.

An important indicator of the Institute's success is the number of alumni who continue in the field of environmental management and research (Figure 3). A significant proportion of alumni can be found working in the NGO community, primarily environmental NGOs (24%), while others continue with graduate studies, also mostly within the environmental field (26%).

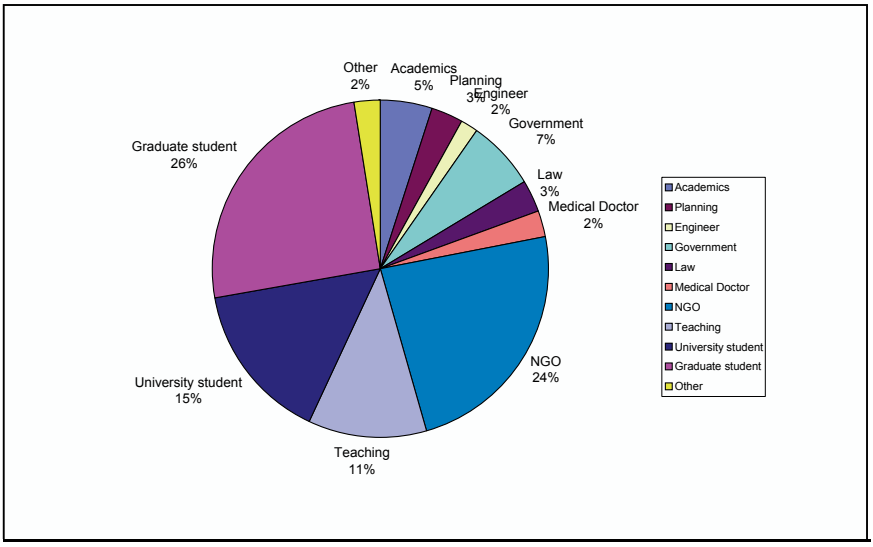

Figure 3. Alumni activities in field of environmental management and research (in percentages).

Recent academic studies have also highlighted aspects of success. According to Schoenfeld and Alleson, the Institute builds on and broadens the social capital of the students in two ways: bridging and bonding (2007). Bridging refers to the ability to transcend ethnic, class, gender, sexuality, religion, or other lines, whereas bonding refers to implying a homogenous composition of participants nested within particular social networks. In this case, students of diverse backgrounds all share a concern for the environment, and it is this concern that bonds the group within a particular social network. The diverse student body of the Institute is a microcosm of the Middle East itself. The intense and long-term immersion of such a diverse student body over a one or two semester program results in bridging social capital. In addition, the common goal of studying the environment in a transboundary context reflects bonding social capital. As such, according to Alleson and Schoenfeld, the Arava Institute is: "…self-consciously a place where a regional environmental narrative is approached as a process of construction rather than a product, where the discourses of environmental management and environmental justice are both acknowledged, and where regional ecological and social transformation is promoted by strengthening the nascent network of regional environmentalists" (2007).

Further research conducted by Chenowyth et al. included a series of workshops, held at three Israeli/Palestinian universities, examining the differing environmental attitudes and understandings of the future that young people hold in Israel and the Palestinian Authority (2007). The three institutions were the Arava Institute, the Arab American University, Jenin, Palestinian Authority and the Hebrew University Israel. According to Chenowyth et al.: "…these foresighting workshops showed that young people can (and do) think systematically and rationally about their future and the future of their environment. Even in a part of the world with a difficult past and present, and a future with many uncertainties, young people are not filled with pessimism but recognize the challenges they face and can identify realistic solutions to those problems which they see as being of the greatest importance" (2007). An additional benefit for the students attending the Arava Institute was a secure context in which to engage the Israeli-Palestinian conflict in as much as it affects the future of environmental security in the region.

4. Research: The PM2.5 'MERC' Project – Israel, Jordan, and the Palestinian Authority

In addition to the academic program, and the social capital that it builds (as described by Schoenfeld and Alleson 2007), the research activities at the Institute also contribute to this social capital in terms of the cooperative work undertaken by professionals in the region. A particularly successful research project is one on air pollution monitoring in urban centers in Israel, the Palestinian Authority and Jordan.

In 2005 The Arava Institute for Environmental Studies launched an air pollution project with two other research teams, one from Al Quds University in the Palestinian Authority and another from the Jordan Society for Sustainable Development

in Amman, Jordan (supported by the US-Middle East Regional Corporation program – MERC). The project has four goals:

- To conduct simultaneous monitoring of ambient PM2.5 (fine particulate matter of 2.5 μm diameter) in Israel, Jordan, and the Palestinian Authority
- To characterize the chemical composition of ambient PM2.5 and identify sources
- To compare results from localities within the same airsheds with different urban activities (e.g. West Jerusalem vs. East Jerusalem, Aqaba vs. Eilat) and
- To produce relevant recommendations for policy makers in order to reduce harmful impacts

and asks four key questions:

- What are the specific sources, components or PM attributes linked to adverse effects?
- How do we know what sources to control to reduce public health risks?
- What is the association between ambient PM and actual personal exposure? What is the association between specific PM components and actual personal exposure?
- Who is susceptible and why?

The project has 11 sites: Tel Aviv, Haifa, West Jerusalem, and Eilat in Israel – Nablus, East Jerusalem and Hebron in the Palestinian Authority – Amman, Aqaba, Zarqa, and Rahma in Jordan. This study is unique because it is the first time that such detailed PM sampling and analysis has been conducted for such a long duration in this region.

There are to be two outcomes of this study: (1) the elucidation of PM2.5 composition, sources, and distribution and (2) capacity building for advanced air quality/health effects research and analysis in the Middle East. In addition, at the project's completion, one will be able to answer four main questions:

1. What is the relative impact of regional sources and local sources of particulate matter in these regions?
2. What are the seasonal variations in sources and composition of PM in these regions?
3. How does the composition and concentrations of PM2.5 compare across sites to monitor PM2.5 in Europe and North America?
4. What are the sources of high particulate matter episodes in this region of the world, and what is the association [correlation?] of these particulate matter episodes with other pollutants such as ozone and carbon monoxide?

There is no doubt that the political situation complicates joint research teams. Logistically, travel restrictions on Palestinians and Jordanians can make simple communication between partners difficult. The potential for travel restrictions and new political developments that can affect travel throughout the region are difficult to predict and can have impacts on a scientific study. Clearly, the complications involved in scientific projects in this region must be considered during all stages of project development. The students of the institute are currently informed about

the scientific progress in the research as well as the political and organizational implications. Nevertheless, during the 10 plus years of work at the Arava Institute, faculty and researchers have successfully, for the most part, overcome such barriers and are forging new ground in transboundary cooperative research that is critical to the long-term environmental security of the Middle East (see also Brenner et al. 2007).

5. Conclusion

The Middle East is a politically complex and volatile region. Regional stability is crucial not only for the area itself, but also for the world at large. Sound environmental policies are a necessary element to ensuring such stability. Issues such as water and energy availability and climate change are all pressing problems in the region and can only be solved through a regional approach based on cooperation. Environmental education is a core element for bringing about environmental and political security. In actuality, the realization is that one cannot achieve political security without environmental security. Institutions for environmental education are thus essential and should be based on studying the environment as a bridge to achieving political and social stability.

The Arava Institute's long-term and interdisciplinary approach provides a foundation of shared environmental concerns upon which to build greater understanding and cooperation and presents concrete options for solutions to the Israeli-Arab conflict and the region's environmental challenges.

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RISK ASSESSMENT IN UKRAINIAN ENVIRONMENTAL HIGH EDUCATION

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Abstract: The training of specialists is a vital factor in achieving environmental security, and an effective system of high education can aid in solving current problems related to environmental security.

The aim of the paper is to consider steps of the Environmental Risk Assessment process in terms of the courses and disciplines gained at Kharkiv National Academy of Municipal Economy (KNAME) that are needed to prepare students to carry out risk assessment.

Environmental Risk Assessment is a valid tool for a number of reasons. The determination, evaluation and management of risks, which result in a decreased likelihood of risks, can facilitate avoiding harmful impact on the environment, protecting human health, living organisms and other components of the environment. Additionally, the risk assessment procedure can be used as a part of an environmental security management system.

This paper addresses the study areas taught at the Academy, including fundamental natural sciences, professional studies, mathematics and statistics, and environmental studies, that could play key roles in the steps of the risk assessment process of *Hazard identification*, *Exposure assessment*, *Dose-response assessment*, and *Risk characterization*.

This paper highlights gaps in the current education program at Kharkiv National Academy of Municipal Economy in the risk assessment domain. This is the area where an international educational experience needs to be applied.

Keywords: education; environmental risk assessment; knowledge; skills; management; gaps

1. Introduction

Since the beginning of human existence, human activity has repeatedly conflicted with nature, resulting in crises of varying scales. Early on, the small population and poor technical equipment kept these crises from manifesting to the global scale (Voronkov 2000).

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During the nineteenth and twentieth centuries, characterized by demographic changes (increasing world population), industrial and technological progress (changing concentrations of chemicals in the environment), and increasing energy consumption, humanity faced global ecological crisis. Anthropogenic influence on the environment has exceeded certain limits, namely, the capacity of the biosphere. The only way to ensure human survival is to reduce global anthropogenic influences and foster sustainable development (Kazachuk and Korol 2004).

An effective system of high education can aid in training of specialists, a vital factor in achieving environmental security. An educated individual with knowledge of integration, managerial skills and interdisciplinary thinking will able to rationalize the essence of current environmental issues, evaluate consequences, and propose steps to overcoming adverse situations (Nazarenko 1997).

2. Environmental Risk Assessment

Environmental risk assessment (ERA) involves the examination of risks resulting from natural events (flooding, extreme weather events, etc.), technology, practices, processes, products, agents (chemical, biological, radiological, etc.) and industrial activities that may pose threats to ecosystems, animals and people. Environmental health risk assessment addresses human health concerns and ecological risk assessment addresses living organisms and other components of the environment (Five Winds International 2004).

The risk assessment process involves scientific and management activity based on a sequence of scientifically practical steps and studies. The aim of this process is to obtain accurate data in order to make the most adjustable decisions on environmental safety. The main stages of the risk assessment process are as follows: *Hazard identification*, *Exposure assessment*, *Dose-response assessment*, *and Risk characterization*.

ERA is a vital tool for a number of reasons. The determination, evaluation and management of risks, which result in a decreased likelihood of risks, can facilitate avoiding harmful impact on the environment, protecting human health, living organisms and other components of the environment. Additionally, the risk assessment procedure can be used as a part of an environmental security management system. In that case, a future specialist would need to know the general methods and approaches of making a risk assessment and proposing solutions to reduce a risk.

3. Environmental Risk Assessment in Environmental High Education

Are the knowledge and skills gained in schools of higher education in Ukraine enough to meet the new challenges of environmental security and make effective environmental risk assessments?

A successful environmental risk assessment requires wide awareness and a knowledge base in many academic disciplines (Tihomirov 2003). An environmental education can be sought at only 8 of the 40 schools of higher education in

Kharkiv. Among these is the National Academy of Municipal Economy (KNAME), where the first department of Environmental Engineering was created in 1991.

During a 5 year program, students study more than 50 different disciplines (History, Philosophy, Economics, Social Science etc.) to obtain a Master's Degree from the department of Environmental Engineering and Management. About 30 of these disciplines are ecological disciplines.

Each step of the ERA process requires certain knowledge and skills. Let us consider steps of the risk assessment process in terms of the courses and disciplines that are needed to accurately prepare students to carry out risk assessment. As the example let us consider a risk of accident in the *City Water-Supply System*, the risk of a pollutant in the water-supply system. This is an acute problem in Kharkiv because basic water-supply maintenance systems have degraded to the point where the chance of technological disasters, failures, and accidents in the city water-supply system are greater.

Fundamental natural science courses (Chemistry, Physics, Biology and General Ecology, Hydrology, Biochemistry and Microbiology, Soil Science, and Applied Fluid and Gas Mechanics) fulfill basic knowledge needs in the whole risk assessment process. Students gain a general understanding of the relationship between living organisms and the environment, the role of humans in a "human – nature" system, main ecological concepts, rules, theories, and scientific facts.

Professional studies (Atmospheric Environmental Engineering, Hydrological Environmental Engineering, Lithological Environmental Engineering, Hydrogeological Environmental Engineering, Urban Sanitation and Waste Management) provide applied skills for solving environmental problems in a particular setting, estimating an acceptable level of anthropogenic impact, and developing techniques to achieve environmental security.

They also play key role in first step of the risk assessment process, **Hazard identification**.

- **Hazard identification** is the analysis of an environmental situation to ascertain if there is the potential for the exposure of an organism (including a human) or ecosystem to an environmental stressor that may cause harm (American Statistical Association 2008).

In this step, the course *Hydrological Environmental Engineering* in particular allows students to develop an awareness of the quality of water based on criterion for a particular type of water-supply system (factors include the composition of water, standards of water consumption, level of water pollution, etc.). This course also addresses and defines different kinds of water-supply systems, systems of treatment, and ecological standards of sewage water content.

The course *Water Treatment and Water Consumption* allows for a general knowledge of the water-supply system: from the water body to consumer through treatment plants, and backward to water body through sewage treatment plants.

With this knowledge background, risk assessors can estimate how harmful a water-supply system could be to human health or environmental media and other organisms by making a comparison with an adjusted standard. This step of ERA

includes making the list of factors which could cause an accident in the City Water-Supply System, identifying and determining hazards.

The second step of ERA is **Exposure assessment**.

- **Exposure assessment** is the process of measuring or estimating the intensity, frequency, or duration of a human or ecological exposure to agents that are currently in the environment, or may be present in the future (American Statistical Association 2008).

Disciplines such as *Mathematics*, *Theory of Chances*, *Mathematics Statistics*, *Informatics*, *and System Analysis* provide knowledge to this part of risk analysis, assessing the probability of adverse events.

The course *Environmental Economics* helps to estimate the structure of risk. It gives techniques to assess the damage.

Hydrological Environmental Engineering and Applied Environmental Hydrology provide information about techniques of assessment of water quality (i.e. after an accident in the water-supply system or after a pollutant has contaminated the water.)

The next step of ERA is **Dose-response assessment**.

- **Dose-response assessment** is the process of characterizing the relationship between the dose of an agent received by a receptor (organism or ecosystem) and the incidence of an adverse effect on that receptor (American Statistical Association 2008).

The objective of this step is to present the relationship between the magnitude of exposure and adverse effects and to answer the question, how is this relationship influenced by factors such as the intensity and pattern of exposure or age and lifestyle of the receptor? *Biology* and *General Ecology* provide knowledge to this part of risk analysis. A *Toxicology* course is not present in the current curricula.

The last step of the risk assessment process is **Risk characterization**.

- **Risk characterization** is the process of estimating the incidence of an adverse effect under the conditions of exposure described in the exposure assessment. It also includes the narrative description of the meaning of the assessment, including uncertainties in the preceding steps (American Statistical Association 2008).

The risk characterization step synthesizes all the information gathered in the three previous steps to estimate the impact of exposure to human health. This step also involves calculation of indexes of the risk: for non carcinogenic risk – *Hazard index*; for carcinogenic risk – *Risk*. There is no such course that could give techniques of that kind of estimation in present curricula.

Additionally, the last step includes **Risk management**.

- **Risk management** is the decision-making process through which choices can be made from a range of opinions to achieve the required outcome. The process involves implementation and control of the taken solutions to reduce risk.

Disciplines such as *Environmental Modelling and Forecasting*, *Information Technologies for Environmental Management*, *Environmental Auditing*, *Environmental Law and Expertise*, provide the knowledge and skills to best implement this step.

There are some ways to manage risk: to avoid hazard, to reduce likelihood of adverse events, to reduce the damage from adverse events, and insurance of risks.

But a method of risk management is not taught in the present curricula. A shortcoming of the current education program, in my opinion, is the absence of a course such as *Environmental Risk Assessment*, which would cover all skills and approaches concerning risk assessment including **Risk management**, the most significant component of the process. This is the very domain where the best examples of environmental education experience have to be borrowed, thus an international education experience should be considered for developing such a course.

This shortcoming is common to the majority of Ukrainian environmental educational degrees. However, there are two methods through which this problem could be addressed:

- Introducing an *Environmental Risk Assessment course*
- Addressing the issues of ERA within secondary postgraduate education

KNAME is following the second method by introducing an Environmental safety Ph.D. program. Development methodology of Environmental Risk Assessment, searching and implementing the most developed forms of Environmental Security Management is the major trend of research according to Environmental Safety Ph.D. program state requirements in Ukraine. Ph.D. projects that are being developed under this program include topics such as environmental risk assessment, methods of environmental safety management for urban water supply systems, environmental insurance, environmentally safe municipal services, and others.

4. Conclusions

Solving ecological problems is always a multidisciplinary task as well as one that involves a risk assessment procedure. This process includes complex formal and non-formal approaches. Objective information is knowledge gained via the study of academic disciplines. Subjective information is knowledge gained through experience, performing risk assessment throughout the whole educational process.

Evidently, there are some gaps in the current education program at Kharkiv National Academy of Municipal Economy in the risk assessment domain. The main weakness of the study is the lack of risk management approaches. It is crucial to fill these gaps because the risk assessment procedure is a significant part of an environmental security management system. Even so, the knowledge and skills gained in the domain of environmental risk assessment help to overcome current regional and global problems of environmental security.

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EDUCATION IN MICROBIOLOGY AS A TOOL TO MEET CHALLENGES OF ENVIRONMENTAL SECURITY

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No other life forms approach the importance of microorganisms in supporting and maintaining all life on Earth.
M.T. Madigan et al. (2003)

Abstract: It has been recognized that the maintenance of human health and well being depends on sustainable development which includes environmental quality. Undoubtedly, the quality of air, water and soil resources, proper management and treatment of wastewater and solid wastes, and a resolving of the connected hygiene and sanitation tasks became priority issues internationally. Only science conesquently applied in education and technology can contribute solutions to environmental problems in a sustainable way. Because humans, plants and animals are intimately tied to microbial activities for the recycling of key nutrients and for a primary formation as well as degradation of organic matter, there is a need for concentrated educational attempts to be undertaken in this field. In examples based on our experimental research we demonstrated the importance of microorganisms, and underlined the necessity of education in environmental microbiology in order to maintain or recover environmental quality in a sustainable way.

Keywords: education; environmental microbiology; sustainable development; organic substances; municipal wastes; plastic materials; health relevant bacteria; groundwater

1. Introduction

Globalization and a continuing growth of human population have not only highlighted the interdependence of nations, communities, and individuals but also made environmental problems trans-boundary in nature and society. In an essay, we discussed similarities which exist in the development of microbial and human communities, and pointed out possible consequences that might afflict single populations, such as human ones, at an energetically depleted and environmentally

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deteriorated natural site (Filip 1996). An example in Figure 1a shows a small microbial colony composed of a single species *(Saccharomyces* sp.) flourishing at a suitable microsite (oil droplet). As soon as nutrients utilizable by this micro-community are spent, or perhaps, the concentration of inhibiting metabolites increases, the same microbial community gets depressed, individual cells becomes site-repelled, and finally the remaining part of the original community dies off. It can happen that a novel, less pretentious but more resistant and usually also much smaller community of microorganisms settles on the same microsite for a period of time (Figure 1b). Nevertheless, sooner or later the new colonizers will have to suffer under their predecessors' fate, too. Perhaps, the microbial life will not be exhausted completely, if some of the last colonizers will be capable of forming endospores, i.e. highly resistant metabolically inactive cells which can remain in a dormant state for a long time.

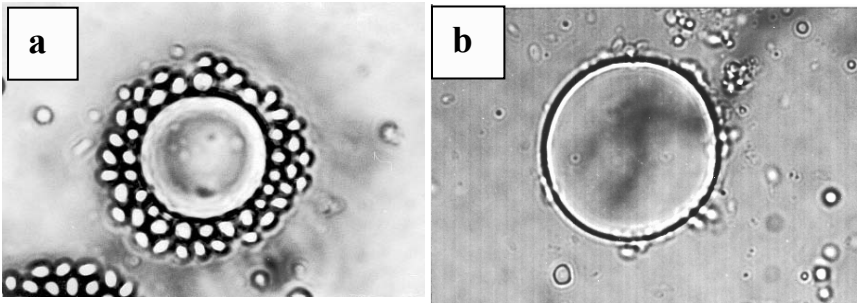

Figure 1. (**a**) Microbial population flourishing extensively on the surface of an oil droplet; (**b**) a poor microbial inhabitance at a similar but impoverished site (Photo: Filip).

In fractions of a 7,000-year old Minnesota lake sediment, viable spores of *Thermo-actinomyces* sp. could be found (Gest and Mandelstam 1987). Even more, Vreeland et al. (2000) reported that endospores of halophilic (salt-loving) bacteria have been isolated from fluid inclusions in salt crystals over 250 million years old. Yet, in contrast to microorganisms which naturally count several thousands of species (Table 1), *Homo sapiens* represents only one single human species. In addition, humans are known as very sensitive organisms; they do not show any natural dormancy, and can proliferate under strongly limited environmental conditions only. Thus, the human population would approach a total eradication for sure if serious deterioration of environmental conditions on Earth should continue further. To avoid any dramatic consequences, not only should public awareness be evoked, but an extensive education which includes lessons in environmental microbiology should be performed at every school and university level. The aim is not only to enhance an understanding of environmental problems theoretically but rather handling them effectively in practice, in order to secure our survival on the planet Earth for many generations to come.

2. Microbiology – A Basic Life Science

The tree of life in Figure 2 demonstrates that life forms visible to our naked eye, such as fungi, plants, and animals represent only a small fraction of the total biological diversity on Earth. In fact, evidently two of the three domains of life, i.e. *Bacteria* and *Archea*, belong to microorganisms, and thus, the main part of the existing genetic diversity is a microbial one. However, in contrast to plants and vertebrates of which about 90% have been explored and described in detail in the past decades or centuries, it is recognized that only about 1% or 5% of bacterial

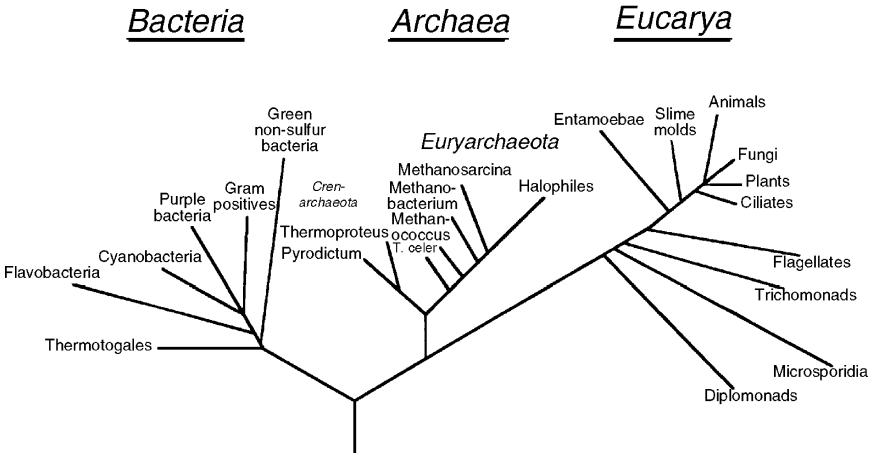

Figure 2. The tree of life – an actual model of the evolutionary relatedness of life on Earth (Leadbetter 2002).

TABLE 1. Approximate numbers (x 10^3) of species in major groups of described and/or estimated organisms (From Staley et al. 1997).

Organisms	No. of known species	Estimated no. of species in total	Percentage of species known from total estimated no.
Microorganisms			
Bacteria	4	1,000	0.4
Fungi	72	1,500	4.8
Protozoa	40	200	20
Algae	40	400	10
Plants	270	320	84
Animals			
Nematodes	25	400	6
Crustaceans	40	150	26
Insects	950	8,000	12
Vertebrates	45	50	90

and fungal species, respectively, have been discovered until now (Table 1). Despite this apparent deficiency, it is microbiology which undoubtedly contributes significantly to our welfare through improved human and animal health, more productive agriculture, and many different actions in order to sustain the quality of environment.

One of the most surprising characteristics of microorganisms is their capacity to perform metabolic activities upon a broad range of environmental conditions. Some microbes thrive in boiling water of natural hot springs or even at temperatures higher than 100°C in submarine vents; other ones can be found living in sea ice of Antarctica. Different bacteria are capable of surviving in saturated salt brines, and some others survive at high levels of radioactivity (Staley et al. 1997). In our laboratory experiments with a microbial community originating from municipal refuse, the count of colony forming units, and the microbial respiration (CO_2 release) demonstrated much higher values at 70°C in comparison to 30°C, and this was especially true if natural colloids such as clays or humic matter were present (Filip 1978). In other laboratory experiments, soil bacteria grew and metabolized strongly in soil samples heavily contaminated with man-made pollutants such as chlorinated solvents (Kanazawa and Filip 1986, 1987). Due to their overall robust metabolism, which includes both mineralization and formation of organic matter, microorganisms turn some 43 Gt of carbon every year, i.e. an amount which corresponds with a total net biomass production on the Earth (Smith and Paul 1990). In this way, microorganisms assure an indispensable recycling of this key element of life.

Undoubtedly, soil is the most heavily microbial-inhabited compartment of the environment. It is the soil microbial community which in a concerted action with other parts of edaphon takes care of a continuing of all basic processes in the organic matter turnover (Figure 3). In each of the individual processes the microbial activities are involved directly or indirectly, and they require specific methodological approaches to be followed and perhaps linked in a desirable way. The same is true for aquatic environments in which basic processes of nutrient cycling and natural food webs take place. We have demonstrated that both soil and aquatic microorganisms are capable of formation of humic substances from simple precursors, which play a dominant role in stabilizing physicochemical conditions in all natural, but also in man-made environments (Filip et al. 1972; Filip and Küster 1979; Claus et al. 1999). On the other hand, complex populations of soil and aquatic microorganisms also have been found capable of decomposing and transforming natural humic substances. In such a natural way the requirements of higher plants and other organisms for nutrients are covered (Filip and Bielek 2002; Hertkorn et al. 2002). It would go beyond the scope of this chapter to demonstrate in detail the manifold involvement of soil and aquatic microorganisms in various processes of environmental importance. Interested readers should be recommended to obtain more detailed information in the sections or chapters by Hurst et al. (2007).

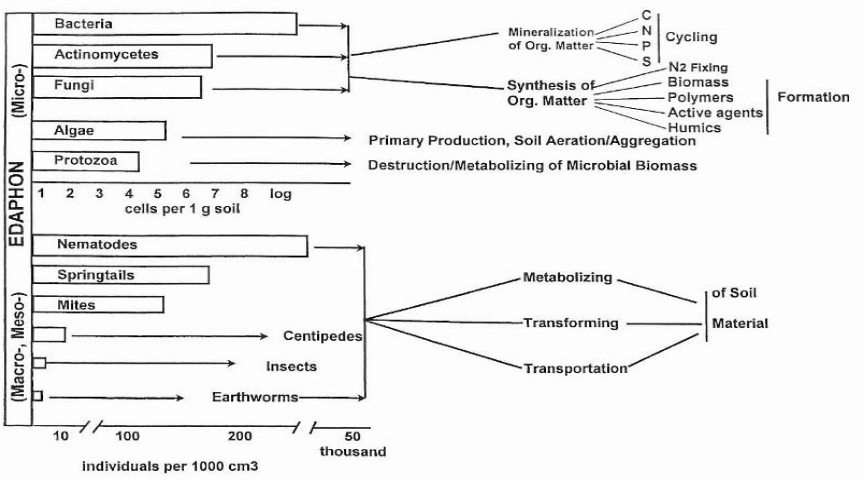

Figure 3. Soil organisms, their approximate counts and activities of basic ecological importance (Filip 2002).

Undoubtedly, the enormous diversity and versatility of microorganisms in all environments constitute an important natural resource. Therefore, there is a necessity for critical genomic surveys of microorganisms in every environment, and establishment of the respective culture collections and data base banks in order to obtain the greatest value from this resource (Payne 1997). Specific areas in which the knowledge of microbial activities can make important contributions in the near future are:

- Human health and disease prevention
- Advances in genetic therapy
- Protection against food spoilage and crop and animal loss
- Development of new food production processes
- Development of novel enzymes for industrial use
- Recycling of wastes, water and industrial and agricultural effluents
- Development of novel feedstocks
- Production of novel polymers
- Optimizing of mining processes, transforming of minerals

In the last decades vast amounts of synthetic materials have accumulated in landfills, and they cause different pollution problems to natural environments. Here, a full understanding of biodegradation and recycling possibilities of these novel materials remains inadequate (Gu 2003). Nevertheless, for some of them such as polyurethane foams, which are widely used in several industries, we demonstrated an effective microbial degradation based on fungal exoenzymes (Filip 1979, 1992). Figure 4 shows an example of the polyurethane deterioration by microscopic fungi. Similarly, a strong microbial growth eventually causing some deterioration was observed on PVC sheets used in power plant cooling-towers (Filip et al. 1983).

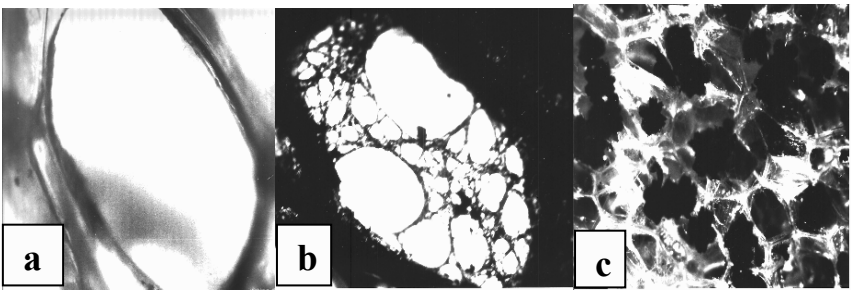

Figure 4. Deterioration of a polyurethane foam (PU) by fungal exoenzymes; (**a**) fresh PU showing an intact thin membrane as closing space between the foam structural balks; (**b**) same membrane deteriorated; (**c**) PU deteriorated, and shown lacking membranes and disrupted structural balks (Photo: Filip).

Harwood and Buckley (2008) pointed out the fact that, among microorganisms, "whistleblowers" exist which are capable of an early signalizing of different types of environmental degradation. This is because microbes and microbial communities are intimately linked with their environments, and in some cases, ecological disturbances become reflected in changes in the abundance or behavior of microorganisms before other outward signs can be detected. Toxic algal blooms, resulting from an excess of nutrients in coastal marine environments, signal pollution. Under certain conditions, the same algal blooms can indicate an enhanced presence of *Vibrio cholereae* (the bacterium that causes cholera disease) in coastal water. Fecal coliform bacteria and other microbes found in the human gut are routinely used as indicators of sewage contamination in water resources. An early detection in environmental microorganisms of genes for degrading human-made chemicals could potentially be used to identify areas of chemical contamination. On the other hand, the detection of some "unknown" genes could reveal useful processes for industry, bring to light biologic issues of which science has not yet conceived, fill gaps in our understanding of different metabolic pathways, diseases not yet understood, and unearth some previously unknown functions of microorganisms in the environment.

In light of the above examples one can recognize the importance of microorganisms in every sort of natural and man-affected environment. Indirectly, it also shows that an urgent need exists in educating young people as well as other parts of the population in this exciting field of science. This should begin early in their schooling and continue through the college days and, for as much as possible, become integrated throughout their years of graduate and post-graduate study.

3. Education and Training to Meet the Needs and Challenges of the Future

Given the central importance of microbial science to biology, and environmental science in general, teaching of microbiology should be thoroughly integrated into school curricula at the elementary, middle, and high school levels. At the ICT

Prague, Filip and Demnerova (2007) suggested the main priority scopes and individual topics as listed in Table 2.

TABLE 2. Priority scopes and individual topics for the lecturing in environmental microbiology and biotechnology as proposed for the Institute of Chemical Technology Prague (From Filip and Demnerova 2007, slightly modified).

Priority scopes	Individual topics
Biological fundamentals	
	Principles of general microbiology
	Microbial energetics and metabolic pathways
	Microbial population and community dynamics
	Microbial substrate utilization and nutrient cycling
	Co-metabolic utilization of refractory substances
	Enzymatic transformations of organic substrates
Ecological fundamentals	
	Microorganisms in terrestrial environments
	Microorganisms in aquatic environments
	Microorganisms in the atmosphere
	Microorganisms in extreme environments
	Animals as microbial environments
	Molecular aspects of microbial ecology
Technological fundamentals	
	Physicochemical principles of technological utilization of microbial activities
	Immobilization of microbial cells on natural and man-made materials
	Formation and utilization of microbial biofilms
	Monitoring of microbial growth and activities in technological processes
	Current possibilities and future prospects in microbial based biotechnologies
Protection of natural resources	
	Microbiological assessment of environmental quality
	Microbial degradation, transformation and immobilization of pollutants
	In situ-bioremediation of polluted sites
	On-site bioremediation of contaminated materials
	Off-site bioremediation of contaminated materials
	Microbial formation of refractory substances in diverse environments
	Survival of health relevant microorganisms in diverse environments

Priority scopes	Individual topics
	Fate of genetically engineered microorganisms in diverse environments
Waste treatment	
	Microbial degradation of organic matter in solid, liquid and semiliquid wastes
	Enzymatic conversion of organic pollutants in different kind of wastes
	Microbial transformation of organic matter by composting municipal refuse
	Microbial leaching or binding of pollutants in landfilled municipal refuse
	Microbial cleansing of waste gases
Health risk and environmental hygiene	
	Detection and risk-evaluation of health relevant microbes in natural and man-made environments
	Hygienic safe handling and treatments of environmental samples
	Environmental and health relevance of microbial green-house-gas formation

The theoretical lecturing which includes the above topics should be accompanied by the respective laboratory courses and practical demonstrations in order to make students familiar with microorganisms in a culture, and with common techniques of observing, evaluating and affecting microbial activities with the aim of their environmentally sound utilization. The young people but also other parts of human society should be made aware of the importance of microorganisms in day-to-day life, many industrial processes, and in environmental protection on a global scale. This means that microbes should take center stage in science curricula at all educational levels. Microbiology should be integrated into all phases of biology education, not segregated as separate coursework. The American Academy of Microbiology makes aware of the fact that achieving such integration in school curricula will require that educational decision-makers themselves understand and acknowledge the magnitude of microbial contributions to life on Earth (AAM Report 2004). According to Harwood and Buckley (2008) and our own specific experiences, the education and training that would help should include:

- Revitalizing of microbial science departments and re-equipment of outdated laboratories with new tools for integrated environmental analyses
- Making microbial evolution and ecology standard components of training in environmental sciences
- Performing intensive courses in (environmental) microbiology which offer students an extensive exposure to the field and networking possibilities

- Developing new textbooks for a better understanding of microbial based life-chains in natural and man-affected terrestrial and aquatic environments
- Establishing of web-based courses and reading lists for all categories of students
- Offering fellowships and travel grants for students and young specialists in order to encourage international cross disciplinary interactions on environmental issues

Keulartz (2005) pointed out the fact that sustainable development is based not only on economic prosperity and social justice, but especially on ecological integrity. The realization of the above listed recommendations on an international scale would substantially contribute to environmental sustainability. Therefore, we have to achieve a well-educated public, versed also in the fundamentals and environmental applications of microbiology. The importance of microbiology must be acknowledged by teachers and policy-makers and translated into meaningful school lessons. As we stated already earlier (Filip 1973, 1996) preventing further environmental problems which might end in a catastrophe for humans and other higher organisms, we must turn away from a primarily anthropocentric oriented environmental protection to the true ecologic, i.e. microbial oriented one. This is an imperative because to warrant a sustainable human life means primarily to better understand and fully utilize capacities of microbial populations which only can secure our survival on Earth.

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PART IV. SUMMARY CHAPTER

ENACTING A DIALOGUE ON ENVIRONMENTAL SECURITY IN HIGHER EDUCATION: AREAS OF INQUIRY AND TOPICS OF DISCUSSION

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Abstract: As the term 'environmental security' becomes widely recognized by national and international organizations as a reference to the potential instances of instability and conflict perpetuated by environmental issues, the relevancy of an environmental education as preparation for such issues has become a pressing topic in higher education. Educators from both NATO Partner and Mediterranean Dialogue counties gathered to discuss the place of environmental security in higher education as it applies institutionally, nationally, and transnationally. Rather than deciding that a particular type of curriculum, set of values, or pedagogical method was the proper outlet, educators and other environmental stakeholders agreed that all environmental education, so long as it is conscious of its ability to impact students' decision making, should begin incorporating themes of environmental security problem-solving as soon as possible. Their discussions outlined core questions educators and administrators must consider in order to adequately prepare students as both global and local citizens.

Keywords: environmental security; higher education; environmental education; educators; sustainability values

1. Introduction

The link between environment and security (environmental security) is a major concern to countries around the world, and is a key priority for NATO, Partner and Mediterranean Dialogue countries. Although the incorporation of environmental security as a vital topic in higher education has become a priority for educators from each of these areas, questions arise as to how this education will be enacted and what form(s) it will take. A variety of interests must be considered when discussing these manifestations given the degree of variance between institutions, while areas of commonality within the shared purpose of higher education allow for exchange and collaboration of techniques. Rather than creating a transnational standard for environmental security, it is important to balance differences

S. Allen-Gil et al. (eds.), *Addressing Global Environmental Security Through Innovative Educational Curricula*,

with the possibility of core sustainability values. The type of education necessary for this action explores our differences while creating a new sense of global awareness and ability to tackle complex problems. Much like the institution itself, as students begin the challenge of confronting tomorrow's ecological crises, their ability to enact true 'security' will entail a level of collaborative action which considers fiscal, industrial, social, legislative, and ecological factors (Landers 2009; Brylinsky and Allen-Gil 2009).

Approaches to environmental security education (ESE) will therefore vary according to the institution's geographic location, pedagogical orientation, academic offerings, and expectations for students upon completion of a degree. Institutions in North America, Eastern Europe or the Middle East, whether with a professional or liberal arts orientation, invested in pure scientific research or business management, and training 'scholars' or 'workers', all must find a place for ESE. Therefore, the incorporation of ESE will require more than a single solution. How should higher education reorient educational systems to enable environmental security as an emergent educational foundation, one which prepares students to understand and solve real issues based on local, institutional factors? Within the educational system, is there a common international agenda for environmental security? What is the appropriate balance between practical and values-based skills? These questions and others were reflected in discussions during the NATO Advanced Research Workshop *Rethinking Higher Education to Meet the New Challenges of Environmental Security*. Participants' inquiries represent major topics in consideration of possible ways environmental security can be enacted in the classroom and difficulties in finding balance between local knowledge and global issues.

2. Challenges and Areas of Common Concern

Defining environmental security, and a common path down which to take global citizens, is a challenge influenced by three main areas of separation. Economic assistance in attending institutions and creating non-traditional educational experiences, balancing and finding worth in both tactile and theoretical applications of knowledge, and expectations for the role of the student upon graduation at various levels were each major areas of discussion between educators. Acquiring a *single* definition and path is not the goal for educators, but mapping areas of agreement, conflict, and future areas of collaboration is seen as crucial to enacting the best type of environmental education. Therefore, the following challenges represent areas of division between nationalities, pedagogical orientations, and desires for student outcomes based on what environmental security entails and where it belongs in higher education. Educators did express the need to explore future possibilities for agreement (though not a desire to come to any single agreement, as diversity in practice and opinion is beneficial to high education), such that students across boundaries, created by physical or theoretical difference, retain common principles or areas for agreement.

Economic considerations related to the institution's country of origin limit or enhance the ability to provide certain experiences (Borysova 2009; Hull 2009).

For instance, though it may be ideal for students to participate in a long-term study abroad immersion such as the Sustainability in Applied International Learning (SAIL) experience provided by The Baltic University Programme (Leal Filho and Mannke 2009), providing funding and staff for a summer-long cruise may be difficult in areas where individual's payment for higher education is demanding, or such programs are not funded by government and industry sources. Institutional endowment and trends in local industry development mandate some limitations on educational experimentation. There are opportunities in countries like Canada, where well-developed co-operative study programs exist. These programs place undergraduate or graduate students with government agencies, industry or consulting firms, to gain real-world experience related to their education, usually for 4-month or summer terms. In Canada, the students are paid well for their work during these placements. However, in Europe, students often are not paid, and in other countries, such as Ukraine, these opportunities currently do not exist at all. The economic norms of the country dictate the opportunity for students.

Participants at this workshop provided valuable insight into the priorities and challenges facing educators today. The insight came from professors, researchers, and students from government, private and academic institutions from 14 countries. Even with this diversity of experiences, participants from all countries agreed that education should result in the development of productive citizens. However, productive citizens may serve many different functions, and therefore the visible impact of past environmental crises and imminence of future issues also mediate educational priorities (Ziegler 2009) – the second area of international separation. Groundwater contamination requires a different set of knowledge than radiation fallout, yet both are issues of local environmental security. For instance, an important ecological problem, and therefore educational focus, for the Republic of Belarus is the radioactive pollution of more than 22% of the country after the Chernobyl explosion (past environmental crises) (Goncharova 2009), while some universities in the United States expressed an educational approach governed by a more macro approach: a set of core ethics that requires students to balance high production with the possibility of negative impacts on social and natural elements within the larger ecological system (future issues) (Gundersen and O'Day 2009). While one national focus affects students by its contemporary presence, another is driven by theoretical implications, making the priority of real-life learning and the scope of environmental security variable on the international scale. Therefore, the third and final issue is the realization that the term environmental studies or ESE "student" can take on a variety of meanings. Students can be citizens, workers, learners. They can be researching, still exploring, preparing for a job, learning for the sake of knowledge, or living as full adults or unprepared young adults. Different 'students' require different types and degrees of education, and will approach their education from perspectives mediated by the previous two concerns.

In light of these factors, NATO workshop participants agreed to discuss several major questions which signify common areas of inquiry among geographic constituents and pedagogical affiliations. First was the discussion of *what* environmental security means to a community of educators which is both local and global

(Brylinsky and Allen-Gil 2009; Khlobystov and Zharova 2009; Filip and Demnerova 2009; Goncharova 2009). Within this discussion was that of whether a common set of environmental values can and should be finalized. From this question participants examined the possibilities for sharing a core ESE curriculum on *how* to prepare students for dealing with issues of environmental security, and the question of *what* institutions of higher education should be taking action on to ensure these topics are components of academic values and curricula.

3. Finding a Balance: Evaluation, Expectation, Valid Experiences

3.1 WHAT DOES 'ENVIRONMENTAL SECURITY' MEAN TO THE EDUCATIONAL COMMUNITY?

Environmental security can take on a number of meanings based on its application in local settings. While environmental security entails concrete instances of ecological difficulty and development priorities in parts of Eastern Europe (Belluck et al. 2005), it is often considered more theoretically in parts of North American and Western European curricula due to higher visibility and economic influence from specific instances in the former. This translates into the educational sector with the importance of theory vs. real-world data emphasized differently across the globe. For example, the metaphor of the "spaceship earth" has been used to capture systems thinking about the limits of finite biophysicial systems (Ziegler 2009) in one setting – clearly a more theoretical or 'possible' approach to teaching environmental stability. Elsewhere, endospores of halophilic (salt-loving) bacteria have been used to explain the variation between sustainable organic life and sustaining human systems of development (Filip and Demnerova 2009) in a far more tangible representation of systems' limits. In the national context, educators in European countries are more often using the local example of Chernobyl to teach students about chemical security issues, while North American professors, though dealing with some tangible water quality issues among others are less likely to engage students with such a locally based approach.

Many educators maintain that the main goal of ESE is to create a foundation of localized, diversified, scientific knowledge which prepares students to understand concrete issues. Often these educators must work within institutions whose requirements for students' and professors' work align with national or state objectives. For institutions whose communities and academic regulations require less tangible production (such as research papers), or those for whom environmental disaster has not yet become a personal reality, theoretical discussions of environmental security more often take place. How the educator perceives him or herself 'as a teacher' dictates their perspective on ESE as well. Many educators from transition countries cited their role as that of developing students prepared to build a sustainable policy or national future. Educators from the United States were more likely to see themselves as guiding students in total thinking skills, and therefore

wished to provide general tools for the student rather than a blueprint to their future actions.

Notably, divisions are often aligned by geographic orientation, for instance "East" and "West" or "North" and "South" perceptions. Yet educators agreed wholeheartedly that these differences were always substandard to the overall desire to allow students to collaborate across disciplines and national boundaries. Systems-thinking, transfer of knowledge from theory to practice, and willingness and ability to collaborate were consistent goals of the educators regardless of background or learning. Rather than attempting to develop a core curriculum of ESE which transcends international differences, it is important to recognize the former patterns of development as guidelines within a variety of unique and locally significant educational styles. The classrooms in different countries need not be similar in structure, so long as the resulting students are equally willing to work with one another in a transnational context.

3.2 VALUES VS. PERFORMANCE

To the extent that values-education may be a part of the environmental curriculum, the institution must question to what extent ethics are being *imposed* versus the extent to which students are being *engaged* in the topic, theoretically and practically. Environmental learning must consider its ethical implications. Ecological resources serve human functions, and are in turn affected by social action. Institutions of higher education must recognize that even skill-oriented learning carries with it values-connotations about the placement of those skills and appropriateness of outcomes due to their application. Issues of environmental security will involve a number of humanistic and personal affiliations; the choices of the future, as guided by a new understanding of systems complexity, will often involve difficult decisions and ethical dilemmas. As such, it is vital to consider the moral implications of ESE in both how topics are taught and what subjects are included. Though it is important to foster a sense of personal investment in issues of environmental security, educators cannot lose sight of science's promise to present all facts as equal.

Teaching students about scientific and personal integrity was identified as important (Hull 2009), independent of one's personal environmental values or leanings. The role of educators is not to teach students whether a particular chemical industry is "bad", nor is allowable for classroom lessons to be influenced by the priorities of clients or sources of research funding. Many educators voiced concerns that ethics and professionalism are often at odds in the instructional setting. Though neither institutional stakeholders, nor any monetary affiliate, should play a part in deciding the ethics of environmental education, it is often difficult to make time for "an education of the heart" (Sipos 2009) when students must also find a practical job. As Rojas (2009) warns, "Institutions involved in the production and dissemination of knowledge, such as universities, all too often promote a culture that objectifies reality while at the same time disconnecting people from each other and from nature". This possibility is mediated by yet another concern.

If environmental security education is to include components of scientific inquiry, should overt ethics be included at all?

The preparation of the student as a citizen is a clear goal of ESE (Sipos 2009). Environmental insecurities have come to bear under the current system of ecological perception, which often divorces the scientific inquiry from its social impact. A system of education which engages the student in critical inquiry begins a process of disengaging that student from previous modes of "scientific development", or rigid standards of progress as a guide for learning. Critical engagement allows educators to guide moral ways of knowing rather than a moral code for learning. Therefore, while one cannot develop or teach a strict set of rules for creating sustainable systems, institutions can foster settings which allow for the acknowledgement of values-education when and where appropriate.

3.3 METHODS OF EVALUATING AND ENACTING ESE

The willingness of institutions to enact values-based learning in their curricula will affect methods of evaluation. Student performance can be evaluated either by product or by development of process. The essential question posed by educators addresses whether the goal of environmental education is to have students who produce good work or students who work well. ESE may provide the platform for an intersection of both types of evaluation and performance. Students studying issues in ESE must work well together, and therefore participate in some coursework which measures their process of inquiry and communication. In addition, another goal of ESE is to find and solve tangible issues with realistic and timely solutions. As such, students must also be capable of certain performance levels or output criteria.

Performance may be favored over process at the undergraduate level, with collaborative process evaluation becoming more important at the graduate and post-graduate levels. In NATO workshop discussions, educators often lamented the difficulty of teaching scientific or collaborative processes to younger students who lacked the foundational ecological knowledge to properly apply those methods. Therefore it appears that the specifics of a core education will vary with local needs, but are necessary to younger students in order to fully appreciate security issues. The product of their work should relay an accurate understanding of physical systems and sets of knowledge, as well as acknowledge the importance of collaborative processes within academic work.

Three major techniques for teaching arise from this conflict of evaluation interests. Workshop participants shared their experience with each type, and also expanded on future areas of interest in which they see their classrooms or departments moving. The first, "road learning", is specific and disciplinary, focused on core requirements within departments in a practical and applied manner. The second, "valley learning", acknowledges broad theoretical paradigms, an exploratory nature of learning, and interdisciplinary work. The third, and perhaps best suited approach for teaching and evaluating ESE, is the "landscape learning",

which combines both perspectives such that core knowledge is retained in micro-analysis work and the importance of sustainability education practiced in the process of broader learning.

3.4 WHAT EXPERIENCES COMPRISE ESE?

Acceptable educational experiences range from basic problem-solving to innovative tactile experiences. Both types of learning represent a continuum of teaching styles, and it is important for an ESE educator to evaluate the institutions' and students' research and learning priorities, ability to access and experience local knowledge and relevant cultural examples, willingness to explore global areas of connectedness, and availability of hands-on learning opportunities before deciding on the right balance of both. Opportunities for creative ESE may be limited by internal (e.g. limited time available outside the regular curriculum) and external (e.g. lack of cooperation from local industry or government) factors. Each type of activity, "product" or "process" based, allows for a disparate perspective and experience with security issues from the student point of view. The continuum is best utilized when a variety of educational experiences can be used in tandem with one another. The experiences which best benefit a student who is attempting to understand the complexity of environmental security issues will vary based on learning style and prior knowledge; developing environmental studies and other educational programs with a wide assortment of experiential learning opportunities ensures a variety of learning styles are accommodated.

Traditional problem-solving courses and projects engage students' ability to understand necessary chemical, physical, and ecological concepts, which can be fundamental to their correct identification of issues in the natural world. Students retain little explicit information in the years immediately following their education. According to educational researcher Edgar Dale, people remember 90% of their experiences and only 10–20% of what they read and discuss (Stone and Barlow 2005). Therefore, rote memorization benefits students little in terms of knowledge retention and real-world applicability, and even less so as they move into higher levels of education. Retention of exact figures is not only unlikely, but unnecessary. Biological systems shift in terms of response and association to the living and nonliving factors around them almost as quickly as methods of measurement can be institutionalized. An understanding of *why* such a figure is important, *how* to calculate it, or in *what* context it can be applied are each more important, easily retained, and valuable types of knowledge which a student can apply in a variety of local or global settings. However, some repetition of basic concepts can be beneficial in cases where key static concepts such as chemical formulas or population growth simulations fall within the area of study. Educators should ensure that students remember a core set of key facts and figures applicable to their particular area of study, and enable students to acquire or refresh themselves on information related to their field and the general field of environmental studies as systems shift in the future.

At the process-centered end of the spectrum, students benefit by directly participating in an action which teaches this type of "knowledge application" learning. Experiential learning ("knowledge application" learning) opportunities take many forms, and can be both highly local, remaining within the classroom or institution, or as global as the classroom limits can expand, including study-abroad semesters or extra-curricular trips. A farm or garden tended by the institution can provide a real-life experiment in permaculture techniques (Gundersen and O'Day 2009), while a micro-enterprise startup in Ecuador allows for mutual benefit to both students and local entrepreneurs (Brylinsky and Allen-Gil 2009). Experiences in the former "local" realm are of particular importance early on in a student's education, as they can easily attach a sense of urgency and value to issues familiar on a personal level with scientific or economic class materials. Personal experience, metaphors, and ways of environmental knowing can be indispensable components to acquiring an 'ecology of knowledge' (Rojas 2009), and must be integrated into pedagogical designs and processes. Explorative learning should be checked constantly with empirical evidence and remain open to peer review, while at the same time, factual learning should be used to ground education in rationality. Moving beyond the classroom makes the possibility, or existence, of environmental issues extremely real to the learner, thereby increasing their personal commitment to learning, and actively working to solve environmental security issues.

4. Environmental Security Priorities for Higher Education

Educators should work to create a global curriculum or standard set of projects, which students, regardless of national background, could participate in, in order to facilitate transnational dialogue. This poses difficulty given the aforementioned variance in institutional needs, yet educators at the NATO workshop agreed that providing some commonality in this type of values-experience could help bridge "thinking gaps" experienced by contemporary political and environmental leaders working to solve global issues. Incorporating a range of experiences for students is a goal of many educators, but the ability to do so can be mediated by the need to provide a particular standard experience which provides measureable criteria for exterior parties. Striking a balance between internationalization and standardization of this type of learning may be difficult, but still pursued by educators across the globe. Place-based learning, whether it occurs in the re-creation of a small local issue in the classroom, or during a month long excursion in the Andes of South America, is essential to the place of environmental security in higher education.

Another issue exists in creating an ESE curriculum of both experiential and problem-based learning. Institutional and local 'agenda-setters' may see less value in these opportunities, which result in fewer tangible results such as original research, scholarly papers, or material testing methods. But the benefits for student, professor, and institution can be numerous if funding and academic expectations allow for experiences in non-traditional field work. For example, the students gain

practical experience addressing an issue as part of a team. Professors and institutions gain a reputation for producing students with practical, problem-solving skills. It is unclear whether non-academic stakeholders such as industry or community leaders, or even institutional staff, should set the agenda for environmental education, yet a matter of reality is that these opinions and others inevitably factor into the final design of educational courses. Given the contemporary and ever-shifting concerns of ESE, some stakeholders may not possess the breadth of relevant scientific and social awareness of educators, and incorrectly assume creative approaches to hands-on learning are not qualified for the higher education setting, for example. Serious debate remains as to which, if any, of these stakeholders should decide the priority of pedagogical approach and application given environmental security concerns, but it is acknowledged that their interests must be practically met in some connection with student needs.

The difficulty of moderating stakeholder and student or learning interests translates into general difficulties in identifying the limits of higher environmental education. Balancing the needs to simultaneously, or in part, teach factual, natural and social knowledge with tacit learning abilities, local social significance, and values-centered collaborative communication, is a tremendous effort for individual educators particularly under the burden of regular course development and institutional requirements. Does the responsibility of higher education to students and society end with a student's ability to learn? Or, should higher education provide the platform for solutions as well, supplying not only the process for solving environmental security issues but the resources and answers to do so?

5. Conclusions

Environmental security is a topic that NATO Partner and Mediterranean Dialogue countries should be actively engaging within the curricula of their institutions. Definitions of environmental security vary within the educational community, particularly between countries whose local experiences with environmental instability or disaster provide absolute local points of focus and those for whom security issues are not yet publicly acknowledged. Resulting definitions will often drive the focus of the academic program interested in teaching ESE. This variability, though initially difficult to accept as 'valuable' within the context of educators wishing to come to agreement on the importance and place of ESE, was inevitably agreed to be a positive facet of higher education. Variability according to local needs will only strengthen individual programs, so long as each subset focuses on the concept as both a local and global signifier. Experiences for students should include a range of learning opportunities from the traditional to the experiential and creative, and examples from attending educators at this conference outlined a wide variety of program-techniques which may provide satisfactory understanding and performance for students wishing to engage as problem-solving citizens post-graduation. Evaluating their collective experiences or providing room for transfer between institutions can prove exceedingly difficult at the international level; this is a barrier which should be discussed by universities and schools across the globe

in an effort to make *collective* and *transnational* education a more viable option for all. This does not entail a devaluation of localized education, which can provide excellent opportunities for values-engagement.

Collaboration on the part of universities – whether with international colleagues or community stakeholders – will reflect on the students' ability to enact a similar willingness for cooperative exchange. The exact evaluation of their experiences must include both a process and product appraisal, and inevitably show that the student is both willing and able to understand, confront, and solve environmental security issues *in tandem* with peers from across a variety of economic, social, and environmental fields. This said, the greatest uniting factor among educator constituents was the imminent sense of timeliness. Environmental security issues in progress are already posing major social problems that students must confront in their personal and academic lives. The time for preparing students to understand and effectively solve issues, or modify ways of doing and knowing such that systems are understood in terms of their environmental and anthropological intersections, has never been more pressing. Though challenging, the road to successfully incorporating environmental security into higher education is beginning to take shape both locally and internationally. Opportunities exist for further exploration and deeper inquiry on the questions posed above. With incorporation of a variety of successful tools outlined by conference participants, suited to variable student expectations and academic priorities, educators and those interested in the value of higher education will find ways to provide the ecological knowledge and process-based experiences necessary for peaceful human existence. In the effort to prepare students, as citizens, for the environmental security issues of today and tomorrow, all educators must think critically about their classroom and institutions ability to teach sustainable development and peaceful collaboration across national boundaries.

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