INTERNATIONAL TECHNOLOGY EDUCATION SERIES

# Technology Education for Teachers

P. John Williams (Ed.)

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**Technology Education for Teachers**

INTERNATIONAL TECHNOLOGY EDUCATION STUDIES



***Scope***
Technology Education has gone through a lot of changes in the past decades. It has developed from a craft oriented school subject to a learning area in which the meaning of technology as an important part of our contemporary culture is explored, both by the learning of theoretical concepts and through practical activities. This development has been accompanied by educational research. The output of research studies is published mostly as articles in scholarly Technology Education and Science Education journals. There is a need, however, for more than that. The field still lacks an international book series that is entirely dedicated to Technology Education. *The International Technology Education Studies* aim at providing the opportunity to publish more extensive texts than in journal articles, or to publish coherent collections of articles/chapters that focus on a certain theme. In this book series monographs and edited volumes will be published. The books will be peer reviewed in order to assure the quality of the texts.

# Technology Education for Teachers

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# TABLE OF CONTENTS

P. JOHN WILLIAMS

# 1. INTRODUCTION

Teachers are under no obligation to accept or develop a philosophy about what they do, but there is an obligation to think about what they do and why they do it; it is irresponsible not to. So teachers need to:

1. think through the issues and alternatives of the various approaches to what they do in the belief that intelligent thought can improve success,
2. consistently base their educational practice on the outcome of that thinking.

A clearly articulated philosophy is one way toward a heightened sensitivity to the challenges of professional responsibility, resulting in consistent, logical practice. This introductory chapter attempts to place technology education in a context – technology education must relate to technology, and is enacted in a school context of general education for all students.

## GENERAL EDUCATION

An approach to general education is usually established by groups of educators (and sometimes politicians) who attempt to distil a consensus of beliefs which represent the social context and the social demands on education. Accordingly, there are three main functions of education:

- the transmission of a culture and a way of life,
- the improvement of the social environment,
- provision for the needs of individuals.

Most countries have statements which elaborate on their educational philosophy. For example the United States has the ten statements of the Imperative Educational Needs of Youth (Educational Policies Commission, 1944), India has its National Policy on Education (Government of India, 1986). Australia has the Common and Agreed National Goals for Schooling in Australia (AEC, 1989), which are typical of the general education goals of many countries. Australia's goals are:

1. To provide an excellent education for all young people, being one which develops their talents and capacities to full potential, and is relevant to the social cultural and economic needs of the nation.
2. To enable all students to achieve high standards of learning and to develop self confidence, optimism, high self esteem, respect for others, and achievement of personal excellence.

*P. J. Williams (Ed.), Technology Education for Teachers, 1–14.*

3. To promote equality of educational opportunities, and to provide for groups with special learning requirements.
4. To respond to the current and emerging economic and social needs of the nation, and to provide those skills which will allow students maximum flexibility and adaptability in their future employment and other aspects of life.
5. To provide a foundation for further education and training, in terms of knowledge and skills, respect for learning and positive attitudes for life long education.
6. To develop in students:
   - skills of English literacy, including skills in listening, speaking, reading and writing
   - skills of numeracy and other mathematical skills
   - skills of analysis and problem solving
   - skills of information processing and computing
   - an understanding of the role of science and technology in society, together with scientific and technological skills
   - a knowledge and appreciation of Australia's historic and geographic context
   - a knowledge of languages other than English
   - an appreciation and understanding of, and confidence to participate in, the creative arts
   - an understanding of and concern for balanced development of the global environment
   - a capacity to exercise judgement in matters of morality, ethics and social justice
7. To develop knowledge, skills, attitudes and values which will enable students to participate as active and informed citizens in our democratic Australian society within an international context
8. To provide students with an understanding of and respect for our cultural heritage including the particular cultural background of Aboriginal and ethnic groups, and for other cultures
9. To provide for the physical development and personal health and fitness of students, and for the creative use of leisure time
10. To provide an appropriate career education and knowledge of the world of work, including an understanding of the nature and place of work in our society.

Goals like these constitute a philosophy of general education upon which school systems and subject specialists base more specific educational development. Specific subjects within a curriculum then become the mechanism to achieve these goals.

## TECHNOLOGY

The relationship between technology education and technology is fraught, particularly in those countries where technology education has developed from a trade or craft focus. Where technology education is being developed as a new subject, for example in China where there is no history of a related subject in schools, it can be organized on the basis of technological principles. However, those countries in which Technology has morphed from other subjects which had a different focus, invariably retain aspects of the traditional subjects. Consequently, a subject called Technology, may only reflect technology to a limited extent.

Technology has a history as long as the history of mankind, which has been documented and discussed elsewhere (Singer, Holmyard, & Hall, 1958). The technology method was used by early humans in the effort to firstly survive and secondly to impact on the environment in which they existed. When a problem was perceived, a solution or a number of solutions would be developed with the best of these being implemented. As the experience of the practitioners developed, knowledge grew and better solutions were developed and new applications of these skills and knowledge were found. The early method was simply trial and error with the knowledge and skills gained from this being passed down to the next generation.

However the history of Technology as a subject worthy of thought and study is much more recent. The history of the philosophy of technology is generally dated from the work of Ernst Kapp, in Germany in 1877. Except for Kapp's work, and an essay on the origins of technology by Espinas in France in 1897, Technology as an area of study has been limited to the twentieth century.

Although technology has played a significant role from the very beginning of human history, in no major writings of the classical philosophers does there exist a systematic treatment of technology (Feibleman, 1982). At times the products of technology have been referred to, but no discussion of the significance and meaning of humans engaging in technological activity. This is surprising given the well established relationship between advances in technology and advances in civilization (de Camp, 1963), and the fact that the one consistent theme throughout human history has been the advance of technology.

It may be relevant to examine the values and attitudes attributed to one of the origins of the discipline of technology, namely manual labour, or work with hands. The most obvious manifestation of this to us as teachers is the attitudes towards technology subjects by school administrators, parents, other students and aspects of society. Studies about technical things that are pursued in a workshop are still regarded by many as second class and for the slower students. Why is there such an attitude?

This attitude is not a modern phenomena, and the historical precedents go back at least as far as the Greeks. In Homer, Hephaistos, the god of the goldsmiths, blacksmiths, masons, and carpenters, was deformed and was the object of the other gods mirth as he hobbled about. He was a divine smith, but the only divinity misshapen and subjected to the other god's mirth. This was in spite of the wonder of his almost magical creations - a throne that could move under its own power, a self propelled tripod, impenetrable armour. Plato and Aristotle share this same mistrust of the marriage of creativity and manual labour, they held the view that those who work with their hands are not truly free men (Chaplin, 1987).

A new respect for technological achievement developed throughout the industrial revolution. Technology developed to be different from what it once was, and since then it has gradually emerged as a system of values and action capable of encompassing every part of human existence. It has become a type of professionalism, a method of organizing society and a way of thinking (Kitwood, 1980). Technology has developed rapidly and ubiquitously to the extent that it is now considered in most countries to be worthy of a place in the core curriculum of schools.

There have been some spikes of public interest in Technology education which should help to reinforce its place in the core curriculum, though it has not been referred to as Technology education. For example the books by Crawford (Shop Class as Soulcraft, 2009) and Anderson (Makers, the New Industrial Revolution, 2012) decry the demise of practical technical activities in schools, and advocate their reinstatement as a way of contextualising important cognitive skills, and avoiding the misguided separation of thinking and doing. As Anderson states:

> But now, thirty years after 'Industrial Arts' left the curriculum and large chunks of our manufacturing sectors have shifted overseas, there's finally a reason to get your hands dirty again. As desktop fabrication tools go mainstream, it's time to return 'making things' to the high school curriculum, not as the shop class of old, but in the form of teaching *design* (p 55).

The assumption of this book is that a philosophy of technology education is an essential starting point for any educational activity in technology. This philosophy is informed in a number of ways, and one of the ways is through an understanding of the nature of technology. Beliefs about technology will determine the content of subjects called technology, and will also determine how they are to be taught. The following discussion about technology covers some of the issues related to technology such as values, determinism, and technology as an area of study.

### *Technology and Values*

Whatever problems technology brings with it, the trouble does not stem from the technology itself, but from the conflicts it creates and the uses to which it is put. There is nothing intrinsically good or bad about technology. It is the way we employ it and the uses to which we put it that create the problems. Given this, the real problems with which we ought to be concerned are the decision making processes we use to apply technology and how we resolve problems with different sets of values (Pacey, 1984, p122). There may be two strategies that represent the extremes of this value reconciliation.

The first is to make one set of values dominant. Conflicts are then resolved by subordination to this master set of values. The argument is that if we are to get on about the business of dealing with technology in a way that increases human potential and decreases misery, disaster, and human suffering, we need to agree on a basic set of values to avoid the debilitating battles that value conflict seems to encourage. This leads to a tough minded fundamentalist attitude, with few compromises.

Another less humanistic but similarly absolute criteria could be that of technological advance, where technological issues would be examined in the light of technological advances and which options would be most effectual. In this scenario, however, there would be no way of measuring competing demands such as the advantages of establishing space programs against more retraining programs for the unemployed.

Another approach is an attitude of tolerance toward ambiguity and a search for compromise. A range of values may then co-exist. Choices will not be seen and black or white, but shades of grey. A range of values would exist in our thinking and education about modern technology. A tolerance of this range of values, and a determination to make creative use of the tensions between human need values and technological advancement values would represent the path to conflict resolution.

Regardless of one's attitude toward technology, no one disagrees that conflict is essentially associated with technology and values. In fact conflict is often used to displace informed technical argument in public debate related to technical issues. For example, when steam locomotives were first introduced in England, it was argued by the opponents of this new technology that the noise from the engines would scare the cows so that they would not give milk. A similar more contemporary example is the effect large wind turbines have on the animals around them. The goal seems to be in such cases to couch the argument in emotional terms that all can understand as a way of swaying public opinion, and as a technique for relieving the anxiety of a technically ignorant public. People may not know if steam engines or wind turbines are good or bad, but all can get behind the idea of milk for children. We see that kind of generated conflict continually, for example with gun laws, and carbon and pollution controls.

Conflict is held to be essential by many. Ellul (1965) sees sources of conflict originating from the quantitative focus of technology and the qualitative aspect of human existence. At the same time technology permits great human achievements, it threatens the annihilation of humanity.

Walden (1981) sees conflict between the perpetuation of the myth of the self made man in the face of an economy of plenty powered by technology. Most people continue to believe that a decent moral life, honesty, and hard work would provide rewards, but in a technological society, this may not be the case.

Butts (1980) holds that a common source of conflict of those technological issues relating to values is between those that provide pressure to conform, and those which tend to alienation, both from nature and from each other.

'Technological fixes' (Weinberg, 1966) are capable of finding shortcuts to many social problems. Because technological problems are intrinsically easier to fix than social ones, we tend to transform social problems into technological problems. For example, faced with the problem of a water shortage, the alternatives are either social engineering - altering lifestyles and ways people use water, or a technological fix such as the provision of more fresh water through more and larger dams or the desalination of sea water. Technology defines the limits within which society can function. By developing new technologies, we can change the limits on society and thereby remove the conditions creating the problem.

In the face of overwhelming technology and consequent conflict, some find consolation in the fact that some values cannot be displaced by technology, and some needs it cannot supply. For example, Paul Goodman (1968), Jacob Bronowski (1964) and Emmanuel Mesthene (1970) agree that while technology is threatening it cannot replace values related to habits, culture and religion. A technological way of thinking:

- remains under the control of values such as the desire for comfort, health, excitement, profit, power, etc. It is for us to balance and direct these values, or to divorce ourselves from the results.
- provides no reconciliation for the problems of moral evil and human suffering. These problems are in evidence everywhere in the world, including technologically advanced societies. While technology often does something to alleviate these problems, it can neither eliminate them nor supply an adequate philosophical answer to their existence.

A teachers attitude toward technological conflict, and their understanding of the relationship between technology, society and the individual, will influence the way they teach technology.

### *Technological Determinism*

Several schools of thought have developed regarding the capacity of people to control the influences of technology. Some maintain that technology is predetermined to develop in a particular way because of certain conditions and events, without the possibility of human intervention (Pannabecker, 1991).

Jacques Ellul (1965) made the analogy between technology and a Frankenstinian monster which man has created that has grown beyond his control. Muller adopted this notion and titled his treatise on the subject "The Children of Frankenstein" (1971). Many writers and philosophers believe that because technology has come to have such a close relationship with the way people live, it dominates human life so much that it determines human values, character and destiny. Lewis Mumford (1934) is another who believes that technology, with its exponential rate of growth, has developed beyond the control of humans and thereby actually dominates and forces people to accept new ways of living and new meanings of the environment.

To those who think that technology has determinative powers over the way people live, technology is not simply the tools that help people do things in new ways. Technology is rather a way of thinking, a new 'world view', a new organization of meanings and assumptions about the world. Some thinkers such as Pierre Tielhard de Chardin, a Jesuit priest and Aurobindo Ghose, the Indian philosopher, agree that technology does dominate human life, but contend that is not necessarily bad. They see a technological way of thinking as a further step in the evolution of man, and part of the divine plan for humanity. The technological society promises to save humanity from limitations, disorganization and irrationality. The values of the individual are not the end of evolution. Technological thinking is a higher mode of thought.

The crucial question seems to be whether individuals are free to do what they want or whether technology forces them to do what it demands. Mesthene (1970) holds that a condition of freedom does remain for people within a technological society, but it sometimes appears that technology is in control because of the complicated relationship technology has with human life. The technological utopians believe technology reduces chaos, brings order, and generally can centralize human effort for the benefit of the public welfare; they are people with social consciences who are driven by their zeal to reform the world, to devise a utopia through technology. Technology is to be safe, aesthetically pleasing and productive of all the finer aspects of civilized life. For example, at the time of the industrial revolution, the mills were to be "lofty airy halls, walled with beautiful designs...the machinery running noiselessly, and every incident of the work that might be offensive to any sense reduced by ingenious devices to the minimum" (Bellamy, 1897).

What a teacher thinks about technology will influence how they teach and what they teach. If a deterministic approach is favoured, then, for example, consideration of the effects of technology on social systems may be not be taught in any significant way because of the considered inevitability of technological development. If a teacher has a more humanistic attitude toward technology, then they will be more likely to foster with their students a critique of technology within a sociological context.

## STUDY OF TECHNOLOGY

The present need to defend Technology Education may not have been as obvious as it now is had it not been for Sir William Curtis, an illiterate Member of the English Parliament in the eighteenth century. The story is that he presented the essentials of education as what we commonly consider to be the Three R's: reading writing and arithmetic, but this was actually a misunderstanding of his original concept (Archer, 1986). The origins of the three R's were a lot more relevant and dynamic. The original triumvirate consisted of:

- reading and writing (literacy)
- arithmetic and reckoning (precision and judgment)
- wrighting and wroughting (how things work, making things)

Had wrighting and wroughting become established as one of the Three R's, the nature of our defence of the discipline of technology today would probably be quite different.

Many writers on the subject of technology consider that it should be treated as a discipline. One of the reasons for this is an attempt to achieve a level of academic credibility for this area which will enhance the foothold technology is developing in academia, but another reason is to try and provide the boundaries within which technology can be contained. Technology can be defined in so many different and equally justifiable ways that are at times so broad as to be meaningless. If the framework of a discipline can be used in the context of technology, then it adds clarity to the boundaries and provides structure that may prevent the dissipation of technology to the extent that no two people agree on its nature.

The academic credibility of Technology has been enhanced by the Society for the History of Technology, which was founded in 1958 and is now a well established and accepted area of academic enquiry. It has university departments, professional associations and scholarly journals.

However some have argued that disciplines with an external non-academic focus cannot be regarded as scholarly or scientific. The argument is that they do not allow for reflection, contemplation, detachment, and those other cerebral qualities that produce true learning.

This rejection of 'the unnatural divide between the thinker and the craftsman' (Sir Lyon Playfair, 1861; Crawford, 2009) is in fact a powerful argument for the academic validity of technology. The unique consideration of both theory and practice in technology leads to a more thorough understanding of reality. Academic learning, disciplined reflection, and practical experience then inform each other. This 'reflective practitioner' (Scott, 1987) has both a broader and deeper understanding than either the practical expert or the academic analyst.

This could be interpreted as one reason why it has taken a long time to establish technology as an area of study, or conversely, why technology, as a discrete entity, is not generally considered worthy of study. Instead of defending an academic orthodoxy and protecting its own 'sacred' knowledge, technology encourages lateral thinking in solving practical problems, not abstract artificial ones. Technology strives to go outside of itself while many traditional disciplines are much more introspective. Technology rejects 'the salami-sliced divisions of intellect and labour and the clear demarcation between theory and practice on which some more academic disciplines rely' (Scott, 1987).

At times this argument is pursued gingerly. The emphasis on Technology Education's intellectual and educational benefits is distrusted by some technologists who suspect an attempt to academize their work. They fear that, in this disguise, wooly thinking, or 'the hollow faddish ideas and snake oil approaches of shallow amateurs' (Hogan, 1991) may drive out good practice.

A balance must be maintained between theory and practice, and between method and product. If the balance is not maintained, and errs on the side of being totally activity based, then prejudice against technology will be maintained. If the intellectual aspects are not balanced, then suspicion will be fostered. The strength of the study of technology lies in the maintenance of that balance.

On the other hand, Technology is indisputably interdisciplinary. Most scholars agree that this is a strength of technology that distinguishes it from other established disciplines. 'Technology has long since burst the narrow banks of engineering (or applied science) and spread out across the wide plains of natural social and human sciences' (Scott, 1987). The proponents of technology as a discipline are left with the anomaly of an interdisciplinary discipline. The interdisciplinarity of technology is vital for it to achieve its full potential and to maintain its broad knowledge base. Some would argue that the interdisciplinarity of technology disqualifies it as a discipline. Because it involves the selective application of knowledge to specific problem situations, the crucial body of knowledge cannot be defined for all situations.

However, the fragmentation of technology into academically convenient packages should be resisted. For example, when universities design degrees in technology to train teachers, there is a danger that the discipline will dissipate all over campus (This is not to imply that it should be taught by educators or pedagogues in order to keep it together). To those who reject technology as a discipline, its interdisciplinarity is one of the rationales used. The point is made that it cannot be a discipline because it is composed of a selective composition from other disciplines. While it does use formal knowledge, the application of that knowledge is interdisciplinary.

A further argument against technology as an area of study is that it is essentially defined in a context, not in the abstract. If the context is removed, and an attempt is made to define technology in the abstract, then all meaning is lost. Technology is essentially activity based, and not possible to define generally in the absence of a specific activity.

The extent to which a teacher feels technology should be approached as a discipline will effect their attitude toward the subject they teach. For example the teachers who approach technology as a discipline will feel less comfortable with an integrated approach to technology where it is taught in all subjects of the curriculum, than its treatment as a separate subject.

## FROM TECHNOLOGY TO TECHNOLOGY EDUCATION

The following are suggestions about the relationship between technology and Technology Education, and what these relationships mean for technology education (Frey, 1989). It is essential that the practical dimension of technology education be significant. Students must have the opportunity to do technology if they are to come to understand its principles and methods. While this component is essential it is not by itself adequate. There are many cognitive technology skills that students must acquire, and a well balanced technology education will provide for these skills.

There must be an integration between technological knowledge and technological activities, and that knowledge which is uniquely technological must be identified, compared with, for example, scientific knowledge. Activities need to be designed not only to be integrative, but to give students the opportunity to identify and use that knowledge which is technological through a design-like process.

The characteristics of a good designer and a good technologist do not always coincide.

Effective technologists tend to be unusually single-minded and completely committed to the task in hand, and do not naturally entertain the resolution of conflicting values that come with design. They favour a quick technological fix to problems and avoid the messy complications of more ‘people oriented’ solutions. This typifies the manner in which we have traditionally taught much technology, a linear unambiguous view of progress and problem solving, with little room for democracy and divergent values. Now design is being introduced into that context, and not without understandable difficulty.

In opposition to this single-minded approach is a more dialectic style of thinking in which views and definitions can be altered, allowing options to open and directions to change, rather than seeing progress only in linear terms. While the institutions of free speech encourage a variety of values to coexist, they depend on a common view about how value conflicts should be dealt with – a democratic value system as contrasted with a technocratic value system.

These two categories of thought are identifiable in design and technology. The consideration of a range possible alternatives to a problem may mean dissipating effort without getting results. While the designer needs to produce original ideas, the technologist works with a design and involves as few original ideas as possible.

### *Balance within Technology Education*

Even a comprehensive review of the literature would not unearth a clear consensus of the organizational principles of technology for education purposes, or even more basically, an agreement on what constitutes technology.

The perceived role technology education is to play will partly determine the philosophy of technology education, and hence the content and methodologies that are employed. The options for technology education have generally been dichotomous and related to either the liberal arts or to vocational training.

There are a number of implications in this approach for both content and methodology. Important content is the concepts of technology, and these can be taught in the context of many different types of technology. The type of technology is not so important, and if it is to remain relevant, should change over time anyway. The social and human implications of the technology are important elements for technology education in a liberal arts context.

The methodology of technology education is particularly important in this liberal arts context because there are a number of identified methods of doing technology, and if students are to develop a heightened awareness of technology then they need to understand and use relevant methodologies. A methodological emphasis will also help ensure that the range of cognitive skills considered important in the acquisition of technological literacy are mastered.

Technology education as vocational training involves the preparation of students for a specific vocation. This is distinct from vocational education. Many subjects have an element of vocational education in that they educate students for entry into vocations. English, maths, science and technology all contribute toward the knowledge and experience necessary in order to enter the world of work.

In vocational training, the particular technological vocation dictates what content is relevant, and it is only relevant to those students wanting to enter that particular vocation. A range of competencies for entering workers are developed by the vocational experts, and when these have been mastered, the student is prepared to enter the vocation. The majority of the competencies are skill based, and the most efficient means of acquisition of these skills determines the appropriate methodologies for technology education as vocational training.

A curriculum model that accurately depicts the scope and nature of technology education should include:

- how technology functions in a persons everyday life
- how technology creates new technology
- how technology produces products and services
- how people use technology to meet their human needs and wants
- how people assess the impact of technology on themselves, environment and culture

## PHILOSOPHY OF TECHNOLOGY EDUCATION

Traditional technology education has questioned the value of a philosophy through its approach to separating thinking and doing. This has implied a sense of inferiority to other subjects, related to technology educators and technology students. But a philosophy does not lack practicality. It offers one of the best possibilities for improving technology education, a reference point for examining concepts and activities in the technological world, a foundation for evaluating and guiding decision making and a basis for speculative thinking and observation.

All teachers have a philosophy about what they do and why they do it, whether it has been enunciated or not. A philosophy will determine how a teacher relates to students and consequent discipline structures, the content of what is to be taught, and how it is taught. For a technology teacher, philosophy will answer questions like what is technology and consequently, what is technology education, how can technology best be taught, who should it be taught to, what should be assessed and how, etc. Teachers do all these things and have a rationale for doing them which may be implicit or explicit. The implication of the discussion throughout this book is that it is better for a philosophy of technology education to be explicit, then it can be debated and discussed, and can provide a logical and defensible rationale for educational activities. Samuel Shermis noted that “all educational issues are ultimately philosophical” (1967, 277), and what is needed is educators who understand the issues at their deepest level.

Educational philosophy is generally slow to change, but society is in a continual state of flux. Given that education is a product of social demands, social changes then represent a challenge to existing educational philosophies. A case in point is the emergence of technology as a core component of the curriculum. This curriculum decision reflects social demands, in that the nature of society has changed over time to become significantly technological, and this represented a challenge to the prevailing technical education philosophy. Technology education is the responsive philosophical change to this social phenomena.

Technology education derives elements of its philosophy from statements of general education, and from those relevant sections of society and the natural world that are related to technology. For example statement four of Australia's goals of education relates quite specifically to technology education. This statement is that education should respond to the current and emerging economic and social needs of the nation, and provide those skills which will allow students maximum flexibility and adaptability in their future employment and other aspects of life. In the derivation of a specific philosophy for technology education, these skills which will allow for maximum flexibility later in life must begin to be identified.

The other source for a philosophy of technology is those elements of society and the natural world that have to do with technology: those that design and create technology, those that use it and those that are effected by it, the raw materials used, and the effects on the natural world. Most sections of society are included in these categories. This fact provides a significant rationale for the importance of technology education in that it is so pervasive, but also creates a problem in that such a study of technology would be very broad.

## CONCLUSION

As Technology Education has been around in some schools and in some countries for a long time, it is surprising that there is still no consensus about what school technology should be, how pupils learn when they study it, and what are effective teaching strategies. Yet in many countries, technology is challenging a number of traditional characteristics of schooling – the decontextualization of knowledge, the primacy of the theoretical over the practical, and the organization of the curriculum along disciplinary lines.

There is a great degree of diversity throughout the world in technology education. This diversity ranges from the absence of core technology education (Japan) to its compulsory study by all students (Israel), an instrumentalist approach (Finland) to a basically humanistic approach (Sweden), a focus on content (USA) to a focus on the process (England), an economic rationalist philosophy (Botswana, China) to a more liberal philosophy (Canada), a staged and well supported implementation of change (New Zealand) to a rushed and largely unsuccessful initial implementation (England), integrated with other subjects (science in Israel, IT in Australia) or as a discrete subject (Scotland).

While the nature of technology education developed within a country must be designed to serve that country's needs, and build upon the unique history of technical education resulting in a relevant technology education program, what happens in the technology classroom is dependent on the teachers' beliefs about technology in its broadest socially oriented context.

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# 2. PHILOSOPHY OF TECHNOLOGY

## INTRODUCTION

Why would technology teachers need to know about technology? Often they are practical people who would like to do practical things in class. To many of them philosophy probably sounds like the most vague and abstract thing there is. Probably it makes them think of what Voltaire, one of those people doing philosophy, once wrote: "If he who hears does not understand what he who speaks means, and if he who speaks himself does not know what he means either, that is philosophy" (Morris 1999). It sounds like definitely something to stay far away from. Yet, I will try to argue in this chapter that the philosophy of technology is something technology teachers may be interested in for good reasons. Perhaps the simplest argument runs like this: teaching about something assumes that you know what it is. The question 'what is….?' is a philosophical question. Therefore the answer to this question given by philosophers should be relevant for teachers. In our case the 'something' is technology. By no means a simple matter to define. Yet, it is important to know what it is because technology educators are constantly asked to justify what they do. Probably no other school subject is so much forced to account for its content and practice. For that reason it is important that technology teachers can draw from a sound theoretical basis to defend the position of their subject in the curriculum (De Vries 2009).

Another reason why teachers would want to get to know more about the nature of technology through philosophy of technology is that international developments cause constant revisions of curricula. If such revisions are not based on a thorough understanding of what is essential and thus needs to be preserved, these revisions will not likely appear to be improvements.

In this chapter I will present the main domains in the philosophy of technology and for each of them show how they are relevant as a contribution to the theoretical and conceptual basis that technology education needs. In the next section I will show how technology education curricula often have biases towards certain characteristics of technology, but also how more and more these curricula tend to become rich blends of different characteristics. Finally, I will draw some conclusions about the way philosophical ideas can become practice in technology education.

*P. J. Williams (Ed.), Technology Education for Teachers, 15–34.*

## DOMAINS IN THE PHILOSOPHY OF TECHNOLOGY

The philosophy of technology is a relatively young academic discipline. The philosophy of science, for instance, is much older. For some reason, philosophers for a long time neglected technology as a possible object for reflection. But in the past decennia the philosophy of technology has gone through a rapid catch-up operation. An often cited book that describes the short history of philosophy of technology and offers a survey of its current domains of interest was written by the American philosopher Carl Mitcham and is titled *Thinking Through Technology*. I will use his description of four basic domains to structure this section of my chapter. Mitcham's structure is based on four different ways of conceptualising technology: as a huge collection of artefacts, as a knowledge domain or discipline, as a set of activities and as a field of human and social values.

### *Technology as Artefacts*

The first important domain in the philosophy according to Mitcham is: technology as artefacts. Artefacts are in fact the outcome of technology, but we often associate them with technology itself. "Look around in your home or on the street and you see technology all around you". Artefacts are the most direct way we get in contact with technology. Ask pupils what technology is and they will most likely respond by listing artefacts. In Technology Education, artefacts play an important role. The outcome of a design project is usually an artefact. Also pupils learn about how certain artefacts work. So we do a lot with artefacts in Technology Education. But what makes an artefact an artefact. What makes it different from, for example, a natural object? That is the question that philosophers of technology have posed also. Their answers are quite interesting for educators, as they try to reduce the description of an artefact to its very basic elements. That is relevant for education, because we do not want to start initially with the full complexity of technology, but always try to make it simple first.

One basic way of describing artefacts is by taking the *dual nature* approach (Meijers 2000). In this approach, we recognise two natures in every artefact. I can describe an artefact entirely in terms of its *physical/structural properties*. Let us take a mug as an example. I can describe the mug in terms of its shape, its weight, its colours, its number of parts, its material properties, etcetera. But if an alien would hear my description, he (it?) would not understand what this object is for. He would, perhaps assume that it is used to keep papers on my desk from blowing away when the window in my office is open. Alternatively, I can describe the mug in terms of its *functional properties*. I can mention that a liquid can be stored in it and carried around, that this liquid can be poured out again or drunk from the object, that sometimes the device informs about its content ("coffee" written on it). For an alien that could give rise to all sorts of images of what the thing might look like. He (it?) may think that is square, thin and tall, or whatever. It is only the combination of the two descriptions that would give the alien a full picture of what a mug is. The two descriptions are complementary and cannot be reduced to only one. I cannot derive the functional properties from its physical properties in a non-ambivalent way and vice versa. This makes the artefact different from a natural object, because that has a physical nature and no functional nature (that is: no human being describes a function to it). The stone in the wood is just there without being used for a function. Of course, I can go to the wood, take the stone and start ascribing functions to it, but strictly speaking, then I have turned it into an artefact, even without changing its physical properties. Functional properties are indeed a matter of ascription, whereas physical properties are not. Functional properties have to do with my relation to the product, whereas physical properties are artefact-internal. The mug's weight or size do not depend on my ideas about the mug, but its function does. I can use it is as mug, but also (thank you, alien) as a paperweight.

A somewhat more sophisticated way of looking at artefacts is to recognize that both the functional and the physical nature can be split up in a more detailed view. The Dutch philosopher Hendrik van Riessen (mentioned with a fair amount of honour as an early philosopher of technology in Mitcham's book) showed that each artefact has to function in many different *aspects of reality*. For instance, they function in the spatial aspect of reality that tells us that everything takes up a certain amount of space. This is something designers have to take into account. It also functions in the linguistic or symbolic aspect, because we use names and symbols to identify it. This is also what designers have to think about. The artefact also functions in the economic aspect: it has a price tag and this depends on what value people will ascribe to it. Likewise, it functions in the social, juridical, aesthetical, ethical and belief aspect. The latter group of functions means that we tend to give trust or belief in technologies (or distrust of course). That, too, is something designers have to consider, if the product is to be a success. In total Van Riessen distinguished fifteen aspects of reality (see De Vries 2005). Another interesting element in his framework is that artefacts can function both as *subjects* and as *objects*, just like humans. But Humans can serve as subjects in all aspects and artefacts cannot. In the physical aspect, for instance, in which we focus on physical interactions, they can be both subject (the ball hits the wall) and as objects (the ball is thrown by a human being). But in the economic aspect, artefacts can only serve as objects: they can be bought, but they do not buy. Designers will have to reflect on the way artefacts are passive or active in the various aspects in order to design them in such a way that they can function as desired.

Let us think a bit more about *functions*. I can ascribe different functions to the mug, but there is always the 'original' function of a mug being an artefact from which I can drink my coffee or tea. That is the function the designer had in mind when designing the artefact and the artefact's physical nature was optimised for that function only. We call it the *proper function*. Nevertheless, I can reason that the same physical nature is also suitable for holding papers down on my desk. That is what we call an *accidental function*. In many cases ascribing accidental functions works because indeed the artefact's physical nature does allow it to be used for that purpose. But there are limits to my options to ascribe functions to the artefact. One day I may decide that I will describe the function of 'fall breaking device' to the mug and happily take it with me when I step out of the 10$^{th}$ floor window of a building, only to find out that the mug's physical properties do not allow the mug to be used for fall breaking purposes. In that case, one could speak of an *improper function*. Another observation about the functional nature is that it makes sense to ascribe a broad range of meanings. Perhaps it would be better to say that the functional nature consists of all user-related properties. Then it comprises not only function in the strict sense (what is it for?) but also such aspects such as aesthetic and ergonomic qualities, price (also a property that is not artefact-intrinsic but a matter of ascription), maintainability, etcetera. By taking 'functional nature' in that way, we have captured all the different properties of the artefact in just these two 'natures'.

Coming back to Van Riessen's theoretical framework again, we can also distinguish other types of functions that are useful for designers to consider. Van Riessen identifies foundational and qualifying functions. *Foundational functions* are related to the origin of an object's existence. A stone, for instance, was formed by physical processes and therefore, Van Riessen would say that it has its foundational function in the physical aspect. A tree, however, was formed by life processes and therefore has its foundational function in the biotic aspect. All human-made artefacts have their foundational function in what Van Riessen calls the formative aspect of reality that focuses on the way entities go through a certain process of development. The *qualifying function* is about the object's ultimate contribution to the meaning of reality. For a painting this function is to be found in the aesthetic aspect, because it is ultimately aimed at being admired for its beauty. Of course it also functions in all other aspects of reality (it has a price tag, it takes space, it can be stolen and thus be the cause of a law violation, etcetera). But the aesthetic function is leading in its design. How about a heart pacemaker? The ultimate aim is that it contributes to a happier life and Van Riessen would seek this in the ethical aspect of reality because he sees love and care as the main values in that aspect. But in order to enable the realization of that qualifying function, it is absolutely necessary that the pacemaker produced the correct electrical pulse. Therefore, it makes sense also to define a *technical function*, which indicates the basic functioning of the artefact that is necessary for the realisation of the qualifying function. Clearly, in this case the technical function is in the physical aspect. For a railway train, the qualifying function is in the social aspect (bringing people together) but this can only be realized when the train can fulfil its technical function, which is in the spatial aspect (going from A to B).

A third important concept related to artefacts, next to functions and a physical realization, is the *operation* (or 'function*ing*') of the artefact. That is what the artefact does when I use it to perform the function by putting it to work. By using knowledge from physics, chemistry and mathematics, I can derive from the physical properties how the artefact will behave when I exert certain actions on it. The effects of that behaviour should match with the desired function.

Artefacts of course can be simple and complex. Often, artefacts consist of many parts that work together. In that case, we speak of the artefact as a *system*. Systems are a combination of parts that work together. That is the description that focuses on the physical nature of the system. The alternative way of describing systems is in terms of their functional nature. Then we see how systems process materials, energy and information as input and transform them into output (again consisting of materials, energy and information). Both on the physical and on the functional side we can describe a *system hierarchy*: sub-parts of parts and sub-functions of functions. To emphasise the importance of the functional nature of the system, nowadays we often find the term *sociotechnical system.* Technical systems can only function in a social context. Even in the case of a single-user system, the social context is important as that individual functions in a social context and the artefact is subject to all sorts of social constraints (economic, juridical, etcetera).

### *Technology as Knowledge*

Let us now turn to the second way of conceptualising technology: as knowledge. In other words, technology is something you can learn or study. It took a long time before philosophers got interested in this way of reflecting on technology (Meijers and De Vries 2009). Until recently, philosophers tended to think of science as knowledge and of artefacts as merely the application of that knowledge. Now we realise that in Technology we do not only apply knowledge but also learn new knowledge from that application. This knowledge can have different characteristics than the knowledge we have applied. In this section, we will examine some of those properties. In the artefacts section, we posed the question how artefacts differ from natural objects. Here we will ask ourselves how technological knowledge differs from scientific knowledge.

A lot of what we know in technology is related to artefacts, as they play an important role in technology. From the dual nature description of artefacts we can immediately derive some types of knowledge in technology: knowledge of the physical nature, knowledge of the functional nature, knowledge of the relation between the two and knowledge of operational principles. Knowledge of physical properties is knowledge of things as they are. That is not different from science in which we also describe things the way they are. For functional nature knowledge, though, this is different. We do not describe the way things actually are, but the way they ought to be. The function of a car is to transport from A to B. That is still the function when it stands still or even when it is in the garage for repair. The function does not describe what the artefact actually does, but what it ought to do when functioning. So functional knowledge is not knowledge about what is (as in science) but knowledge about how things ought to be. We call that *normative knowledge*, in contrast to *descriptive knowledge* (as in physical nature knowledge).

We can easily recognise the difference in the following example. For an engineer it makes sense to claim: "I know that this is a good screwdriver". For a scientist, though, it makes no sense at all to claim to "know that this is good electron". That is because the engineer's knowledge refers to what the screwdriver ought to do. For the scientist there is no 'ought to' in the electron's behaviour. Either it does what all electrons do and then it is an electron, or it does not and then it is not a 'bad' or a 'broken' electron, but it is no electron at all. In the engineer's case there can be levels in normativity. He can not only claim to know that this is a good screwdriver (that is, this particular *token*), but also that a certain *type* of screwdriver is good.

Another property of technological knowledge that distinguishes it from scientific knowledge is the extent to which technological knowledge is generalized. In most cases, science tries to generalise as far as possible. Physicists are looking for the 'Grand Theory of Everything'. Engineers are not interested in such a theory as it is way too far from the actual (design) problem they are dealing with (De Vries 2010a). They need a theory that goes beyond one particular situation (otherwise it makes no sense storing that knowledge) but not too far. In order to be useful, technological knowledge is much more *context-specific* than scientific knowledge is.

A third distinguishing property of technological knowledge is that its content is often a matter of (social) *agreement*, more than a matter of a conclusion that necessarily follows from observations, as in science. Of course in the process of determining what theory to accept social processes play an important role, as the social constructivists have shown, but scientists cannot freely decide, for instance, what the electric charge of an electron is. Engineers, on the other hand, can freely decide what the norms for an M3 bolt are. Of course they will have reasons for deciding, but in the end they are free to decide as they want because there is no 'natural necessity' for an M3 bolt to be sized as it is.

A fourth characteristic of technological knowledge is that it is often of a *non-propositional* nature. In science, knowledge is usually expressed in propositions, or sentences that contain a certain truth. Such propositions can be: "the relative density of water is 1 kilogram per litre", or "the electric current in a wire is proportional to the voltage over it". In technology, however, much knowledge cannot be expressed in such terms, or only at great cost. Engineers often express their knowledge in drawings, mock-ups, maquettes, prototypes and the like (Baird 2004; Ferguson 1992). They could try to describe the same knowledge in a tremendous list of propositions but even then they would feel that part of the knowledge expressed in the drawing or whatever was lost in that process. The same holds for knowledge that is usually called knowing-how. I know how to hammer a nail into a piece of wood, but I cannot express this knowledge fully in sentences. This, by the way, has great implications for teaching that knowledge, because then it cannot be taught by writing it in a textbook, as textbooks can only contain propositional knowledge and to some extent knowledge that is expressed in drawings.

A well-known taxonomy for technological knowledge was developed by Walther G. Vincenti (1990), based on a series of historical case studies in aircraft design. He defined six types of technological knowledge, as follows:

1. Knowledge of fundamental design concepts. He distinguishes two sub-types: knowledge of basic parts of a design (for instance: an architect know that designing a skyscraper means deciding about a foundation, a core and a covering), and knowledge of working principles (e.g., of the lever principle).
2. Knowledge of criteria and specifications. Engineers know what type of things to take into account when reflecting on the user/customer.
3. Knowledge of theoretical tools, such as formulas derived from physics and math, or CAD programmes.
4. Knowledge of quantitative data. Vincenti distinguished two types: knowledge of quantitative descriptive data (e.g., the specific heat of a substance) and quantitative prescriptive data (e.g., the size of an A4 paper sheet or the size of an M3 bolt).
5. Knowledge of practical considerations, e.g. knowing how to decide if there is a conflict between safety of the design and cost.
6. Knowledge of design strategies, that is knowing how to approach a design problem.

Although Vincenti makes no effort to argue for the completeness of this list, it does give a good insight into the variety of knowledge that engineers can have. It is not difficult to recognize the four characteristics mentioned earlier in the various types of knowledge Vincenti defined. Another interesting feature in Vincenti's book is that he investigates the sources for technological knowledge. He made up a whole list, containing, for instance, theoretical and experimental work in engineering sciences, but also direct trial and production. Deriving knowledge from natural science also features in this list, but Vincenti then goes on to show that this type of knowledge source only contributes to two of his knowledge types, namely knowledge of theoretical tools and knowledge of quantitative data. This gives him a good reason to criticize earlier writings in which technology was presented as 'applied science'. Evidently, applying science would be a very incomplete source of knowledge for engineers. Therefore, we can claim that technology and engineering are domains of knowledge that are really original and not just derived from science.

Another way to look at the relation between design and knowledge, next to Vincenti's approach, is to see how design and knowledge from science interact. Here, the Dutch philosopher of technology Andries Sarlemijn has done some interesting analysis. According to him one can distinguish three types of technology by observing how science and technology interacts:

– *Experience-based technologies*. In these technologies designers come up with designs without exact knowledge of how they work. It is only when scientists afterwards study the artefacts they come up with and learn from those that such an understanding becomes available and often it does not even lead to improvement

of the artefacts. Examples of such technologies are simple household devices and tools.
- *Macrotechnologies*. In these technologies the development of scientific knowledge interacts with the development of artefacts. Usually it starts with the artefact. Steam engines, for instance, were originally designed without correct knowledge of what happens inside the engine. But as improving the design seemed difficult without such an understanding, engineers called in scientists to investigate this and thus thermodynamics developed as a new area in science. This new knowledge led to improved engines, which called for more advanced knowledge to improve them even further, and an alternation of design and science emerged. They are called macrotechnologies because typically they are devices in the design of which classical theories about behaviour on the macrolevel is involved.
- *Microtechnologies*. In these technologies, no substantial progress is made in design without previously acquired scientific knowledge. The history of the transistor nicely illustrates this. People at Bell Labs had tried to copy a bulb amplifier in solid state, but it did not work properly. It was not until they started applying solid state theories about energy bands that a functioning transistor was developed.

Although there may be exceptions to Sarlemijn's taxonomy, generally it gives a good overview of the variety of technologies. It again shows that technology and engineering are more than a matter of applying natural sciences, which would only lead to microtechnologies.

### *Technology as Activities*

The third way of thinking of technology is by recognising the activities or processes that characterise it. Roughly speaking, three types of processes can be distinguished here: designing, making and using/appreciating processes. The first two are very much the professional domain of the engineers and technicians, the third is something all citizens can be involved in (although many of them also do design and making work, for instance, as a hobby). In the philosophy of technology, so far nearly all that has been written about technological processes is about the design process.

Taking again the dual nature approach as a starting point, how can designing be characterised? Designers begin with a desired functional nature. This is expressed in the assignment that they start with. They may refine it in conversation with customers and users and transform it into a list of requirements. Their ultimate challenge is to come up with a physical nature that can realise this desired functional nature. This activity requires two different types of reasoning. To get from a desired functional nature to a physical nature that enables the realisation of that function (via the functioning or operation of the artefact), one needs *means-ends reasoning*. This is an example of practical reasoning, that is a type of reasoning that leads to an action as the conclusion.

Once a possible physical nature has been designed, one can predict the behaviour of the artefact through *cause-effect reasoning*. This is an example of theoretical reasoning, that is reasoning that leads to a factual proposition as the conclusion.

Much has been written about the process of designing. In the discipline of *design methodology*, the original ambition was to develop prescriptions for designers that would be product-independent and usually based on the phases of analysis, synthesis and evaluation (Cross 1984). Soon, this appeared to be too rough a simplification of the complex design processes that were encountered in reality. Therefore observations of such real processes were done and it appeared that design processes are much fuzzier than one had thought earlier on. Even prescriptions for specific engineering domains were problematic, although in books for engineering students such prescriptions are still present and taught. The more recent insight is that each method has its own *assumptions* in terms of what the designer using it should know and should be able to do. Methods that aim at translating customer requirements into technical specification, for instance, usually assume that companies can identify precisely who the customers are, and that customers know what they want. Both assumptions are by no means obvious and certainly not fulfilled in all situations. In those cases the use of such a method may be problematic.

A trend in design is to take into account the whole product lifecycle in the design as early as possible. This relates to the idea that designers should think of every aspect in the whole lifecycle that offers opportunities to please the customer. This is called *total quality management*. This idea has led to a whole series of design methods, often called *design for X*. For instance, there is: design for production, design for manufacturing, design for logistics, design for cost, design for maintenance, design for recycling. The last-mentioned example is part of *green design* or environment-conscious design.

Not much has been written in philosophy of technology about the production process, but some notions are worth mentioning here. Production can be seen as a transformation of materials, energy and information. When beer is produced in a brewery, various materials are used (water and hops, among others), energy of whatever kind is transformed into heat, and information is processed in the form of temperature prescriptions, timing for the various sub-processes, and monitoring of various properties of the brew. When looking at the role the resources of energy and information play in production, one can distinguish three types of production processes:

– *Manual* production: in this type of production, humans deliver both the energy and the control (information); production happens by bear hand or with tools;
– *Mechanized* production: in this type a machine delivers (most of) the energy, but the control (information) is still delivered by humans; production happens with machines
– *Automated* production: in this type of production, both the energy and the information come from an automaton during the production process; production happens with robots.

### *Technology as Values*

The fourth way of conceptualising technology is: technology as values. This way of reflecting on technology makes connections to metaphysics (what kind of view on reality do we hold?), ethics (values of good and bad; De Vries 2006) and aesthetics (values of beautiful and ugly). It is the way of looking that was the focus of early philosophy of technology, when Continental philosophy still dominated. Continental philosophy was the philosophy as practised by philosophers that lived and worked on the European Continent such as Heidegger, Husserl, Marx and Sartre, to mention just a few. Their philosophies are very much about values. The other main stream in philosophy is analytical philosophy that aims primarily at developing well-defined and logically consistent concepts. Analytical philosophy dealt mostly with the previous three ways of reflecting on technology (as Artefacts, as processes and as knowledge), while Continental philosophy of technology was particularly interested in technology as values. Currently we find representatives of all main streams in philosophy reflecting on technology. We will now show how the various main streams in Continental philosophy have developed a philosophy of technology.

Let us start with the *phenomenologists*. They go in the footsteps of Heidegger and Husserl. Heidegger had a very gloomy view on technology. According to him, technology made us look at reality as a resource. Technology has made us unable to appreciate reality as it is. When we see a tree, our first thought is not: “o, how beautiful”, but rather: “how many planks can I make out of that tree?”. This is of course a distorted view of realty, but according to Heidegger it is embedded in our thinking so strongly, that “only a god can save us” from it. As Heidegger did not believe in the existence of a god this means a view without hope. A contemporary philosopher of technology who extended this view is Albert Borgmann. According to him, devices have a place between us and reality so that we are much less engaged with reality than before (Borgmann 1984). To heat a room, we no longer go into the forest, chop wood and carry it home, but only slightly twist the thermostat and the commodity of heat is there for us. Not much engagement left there. In a similar way, we do not go to a shop, buy ingredients for a meal and cook it, but we buy a ready-made meal in a plastic box, put in a microwave oven and push the button. Rather than playing an instrument, we insert a cd into the player and – again – push a button. In general, our engagement with reality has been reduced to pushing buttons. This is what Borgmann called the *device paradigm*. He sees only one way out: increase engagement by *focal activities*. Those are activities that do require engagement, such as: cooking our own meal, jogging, or attending a church service. Borgmann realises that our economy does not allow for fulltime focal activities, but he pleas for a two-part economy, one part of which is based on the device paradigm and the other part on focal activities, so that at least we keep being reminded that there is more than devices.

Another phenomenologist is Don Ihde, and he has a more positive view on technology as impacting our experience of the lifeworld. According to him, technology can serve as an intermediary between us and reality in four ways (Ihde 1990). The first way is the embodiment relation, in which a technological device through which we experience reality becomes almost one with our own body. People who wear glasses do not notice anymore. A second way is the hermeneutic relation in which technology makes a translation of reality that we perceive and that needs interpretation in order to be understood correctly. A physician studying an MRI scan has to interpret the picture correctly in order to make a correct diagnosis. Ihde's third way is the alterity relation in which the technology alters reality (or even shapes an entirely new one) that we look at, such as in the case of a computer game or a science fiction movie. The fourth way is the background relation in which the technology creates a background noise or smell or light that we are not aware of but that does influence our perception of reality (that is why we do not see so many stars in the night sky in a city). Ihde claims that as long as we are aware of the way technology influences our perception, this need not be a problem (it can even enrich our perception, because we see things that otherwise we could not see), but misunderstandings can occur when we do not realise this.

Let us now move to the next main stream in philosophy, namely the *Critical Theory* (or Frankfurter Schule). This stream does not focus on the individual's perception of reality, like Heidegger and the phenomenologists do, but on the social dimension of reality. Philosophers in this stream show how technology impacts society and the other way round. They take a neo-marxist approach in that they acknowledge the fact that Marx's expectation that capitalism would necessarily collapse did not happen and that apparently measures were needed to make this happen. One of the philosophers of technology in this stream is Andrew Feenberg. According to him what must happen is that technological developments go in two steps: primary and secondary instrumentalisation (Feenberg 1995). In the first step a socio-technical problem is separated from its social contexts and solved by engineering. In the phase of secondary instrumentalisation, the solution is put back into the social context whereby society can make alterations to the technology and its function. Feenberg gives the example of the French Minitel system, that was originally designed to enable the French government to disseminate information through a network of terminals in shopping malls and other public places, but that was later taken over by hackers to exchange information. Thus a democratisation of the technology took place in the phase of secondary instrumentalisation after the primary stage had resulted in a centralist information system. Feenberg believes this should more or less be the pattern for all technological developments.

Another important stream in philosophy is *pragmatism*. John Dewey was an important representative of this stream. Pragmatism claims that what is true is what works (that is pragmatist epistemology) and what is good is what works (that is pragmatist ethics). Larry Hickman has taken Dewey's ideas about learning by experience and has applied it to technological developments. According to him what engineers do should be the model for all social decision making (Hickman 2001).

Engineers do not have prefixed ideas about what a technology should look like. They try out options and the one that works best is the one they choose.

Finally, I want to mention those streams that are based on religious points of view. One these is *reformational philosophy*, and this philosophical approach has particularly contributed to developing ideas about the nature of technological developments and moral values in technology (De Vries 2010b). In his book *Thinking Through Technology*, Mitcham mentions Hendrik van Riessen as a representative of this stream that in a very early stage of philosophy of technology had already developed many ideas about the nature of technology as a process in which potential sense in reality is opened up (disclosed) in designing and making activities. Egbert Schuurman continued his work by pointing out that different motives can be behind this: motives of lust for control or of care and stewardship. Currently, philosophers of technology in this stream (Hoogland, Jochemsen, Van der Stoep, Verkerk and De Vries, to mention just a few) show how the concept of practices (coherent totalities of human actions directed towards certain internal and external goods) can be used to show how normative issues play a vital role in all technological developments.

This small survey shows the variety of approaches that are present in the 'technology as values' way of reflecting in the philosophy of technology. It is evident that this way of looking at technology offers many options for dealing with social and moral issues in technology education. But also the other three ways of reflecting on technology (as artefacts, as knowledge, and as activities) are relevant for technology education. Let us now turn to the question how philosophy of technology can be used as an input for technology education.

## TECHNOLOGY EDUCATION AND THE PHILOSOPHY OF TECHNOLOGY

When we start with the 'technology as artefacts' approach, it is evident that this is one that certainly appeals to pupils. Studies in the Pupils' Attitude Towards Technology (PATT) tradition have shown that many pupils can only think of technology as the large set of artefacts that we see around us (De Vries 2005). In technology we want them to have a more balanced view on technology, but at the same time we have to acknowledge that artefacts indeed play an important role in our daily lives and that it is important that pupils have an understanding of what they are and what they do. A problem here is that there are so many and that most of them are complicated to explain. Here the two natures of artefacts, as conceptualised in the philosophy of technology, can be a useful tool to teach about artefacts.

1. Rather than beginning with the complexity of many artefacts, we can start helping pupils to get a first, basic understanding of artefacts by making them reflect on the physical and the functional nature of the artefact first. The elegant simplicity of the dual nature approach is appealing for teachers as education almost by definition looks for ways in which complex things can be simplified to make them teachable and learnable. Once they have learnt to recognise the two natures

in artefacts we can move on and introduce basic concepts like operation of the artefact and the ways in which the two natures are connected in design work. This approach can be extended to systems in a next step of understanding.
2. In a similar way, the 'technology as knowledge' approach can be used to derive implications for teaching and learning technology. The normative dimension in technological knowledge, as identified by philosophers of technology, for instance, makes us aware of the need to teach not only how things are, but also about how we would like things to be. Pupils must learn to develop ideas about how things can be improved and in what respects. They must also learn to see technology as a matter of decision making rather than a matter of necessities. That is why technological knowledge often is the outcome of decisions rather than of measurements. Using a taxonomy for technological knowledge like Vincenti's can illustrate this for pupils in a practical way. This characteristic of technological knowledge (it's normativity) also brings in ethical and aesthetic issues as a highly desirable component in technology education.

The lessons learnt in design methodology ('technology as activities') can be used to develop design projects that do not suffer from the naïve ideas people had in the early days of that discipline. In technology education, as in the world of real design, we have to acknowledge that design processes are fuzzy to some extent by nature and vary between different types of products and technologies. Still we can find simple flowcharts for design processes in course material and we have to be cautious not to let these make pupils think that design is simply a matter of following the steps one by one. Such flowcharts can fulfil a useful role in helping novice designers to learn how to become more independent of such fixed sequences of steps. The idea of scaffolding in current educational theory supports the idea that flowcharts can serve as a useful support that gradually can be taken away when pupils become more acquainted with design work. Thereby we have to make sure that the flowcharts do not become a straitjacket when we keep using them too long. We also have to be aware of design processes in which knowledge is both used and developed. We have to build in moments in which pupils have to be conscious of potentially useable knowledge they already have, but also moments of reflection that make them aware of new knowledge that they have gained during the design process. This can be both knowledge about the process of designing as well as knowledge of the content matter. Building tall structures, for instance, may have taught them about stability, but we have to make this learning explicit if this knowledge is to be useful for later design experiences.

Finally there is the approach of 'technology as values'. From literature in this approach we can find lots of opportunities to help pupils develop their own normative ideas about how technology should function in society and in their own personal lives. I would like to mention the option of using science fiction movies as a practical means of bringing this into the classroom. Often, pupils have seen such movies but not recognized the sociotechnical issues that are raised (often in an exaggerated way to make it more visible) by the filmmakers. Movies like 2012, the Day After Tomorrow and Waterworld make possible effects of environmental problems visible in a speculative, but impressive way. Movie such as Gattaca, The Island, The Sixth Day direct attention to possible damage to our human identity and personality when technology makes us value human life only on the basis of DNA, organs and other physical aspects of our humanity. Some of these movies are certainly not suitable for younger ages, but even for those children there are sometimes very suitable options for using movies. The charming Disney/Pixar animated movie WALL-E can be an excellent tool for making younger pupils reflect on what an unlimited use of technology can do to our world and to our personalities.

I hope I have made clear that all four approaches to reflecting on technology can have implications for teaching about technology. I think we have only just begun to exploit the rich resources that are available here. Perhaps it was a lack of awareness of these resources that have caused certain biases in the way technology education curricula have been developed in different countries. This is what we want to turn to now: what type of approaches have been used in turning aspects of the nature of technology into curricula in the past in different countries. After having described some approaches in their pure form, I will show how today we find many blends of the different approaches in current curricula for technology education (De Vries 1994).

## APPROACHES TO TECHNOLOGY EDUCATION

### *Orientation towards craft skills*

Probably the oldest approach to technology education is the craft-oriented approach. Most technology education curricula have emerged from craft-like subjects in the school curriculum. Still today, we can find technology education is very much like that (Denmark, Austria and Switzerland are examples if such countries). In this approach the focus of technology education is the learning of craft skills. Pupils usually make pre-designed artefacts and the outcome is assessed mostly on the basis of the quality of the artefact, not the process. One could say that in this approach a particular type of activity ('technology as activities'), namely the manual making process, is emphasized.

### *Orientation towards industrial production*

In this approach again a making process gets all the attention, but here it is the mechanized and automated production process. This approach was dominant in the former Eastern-European countries as production labour was seen as the heart of society in the communist ideology. Pupils were made familiar with the industrial production process. Here, too, they made pre-designed artefacts, but now often in the school version of a production line. This and the previous approach often feature in technology education in a vocationalized version. In such a version the primary purpose of technology is seen as preparatory for a technical study and not for general education. This version is still popular in a lot of countries.

### *Orientation towards design*

This is the third approach in which an activity is the focus, but here it is the design activity. The country with the longest tradition in this approach is, no doubt, England. Primary purpose of the curriculum is to stimulate creativity and design skills through projects in which pupils make and then materialize their own design. Often the range of topics is very wide and certainly not limited to engineering. Food and fashion may also be included. The assessment of the pupils' work is mostly based on the process and to a lesser extent the product.

### *Orientation towards 'high tech'*

In this approach the 'technology as artefact' aspect of reflection on technology is emphasized, and with a preference for the more advanced artefacts, such as computers, robots, automated systems and the like. Pupils learn about the construction and operation of such artefacts and systems. Simulations of such artefacts are often included in the classroom activities. It will be clear that this is a fairly expensive approach to teaching technology. In countries like France and Israel that like to promote themselves as high tech countries this approach is often practiced. The unsuccessful effort to introduce this approach in South Africa shows that it requires a lot of the school's budget and infrastructure.

### *Orientation towards application of science*

This is an approach in which knowledge is highly appreciated, but it is scientific rather than technological knowledge. This approach is often practiced in the school subject 'science' rather than 'technology'. Technology is seen as an attractive context for teaching science. Scientific knowledge is used to explain the operation of technical artefacts. In that sense, it is an approach in which the 'technology as artefacts' reflection mode on technology is the primary focus. We can see this approach in many countries worldwide.

### *Orientation towards key competencies*

The key-competencies-oriented approach is one in which 'technology as knowledge' is the focus, and particularly knowing-how is at the core of the curriculum aims. For some time this approach was strongly supported by industry in Germany, as companies saw skills like cooperating, organising, presenting, taking initiative and responsibility as the key competencies they would like their workforce to have. In this approach pupils do a lot of project work, often with an industrial flavour. Of course there was always a relation with technology content, but the assessment was based primarily on the key competencies.

### *Orientation towards engineering concepts*

Here again we have an approach in which 'technology as knowledge' features strongly. Now it is the more theoretical knowledge that is taught and learnt. It was quite a struggle to find out what basic engineering concepts are, but gradually concepts like 'systems', 'matter', 'energy' and 'information' emerged (Wolffgramm 1994). This approach was popular in Germany and pupils were asked to make theoretical analyses of systems in which they had to identify the flow of matter, energy and information.

### *Orientation towards social aspects*

In this approach it is the 'technology as values' way of looking at technology that gets most of the attention. In the early years of technology education in Sweden this approach was popular. Pupils learnt about social impacts of technology and ethical questions were asked concerning technology and humans. One could also say that many of the STS (Science, Technology and Society) curricula were framed according to this approach. Activities could involve real situations in the local context of the pupils.

### *Blending of approaches*

Due to the increased international exchange of ideas and information, most countries now have a curriculum that no longer has only one of the approaches listed above as its main focus, but rather a blend of different approaches. In the USA Standards for Technological Literacy (ITEA 2000), for instance, one can clearly detect elements from all approaches mentioned above. Also the UK curriculum is definitely richer than design only. New Zealand is another example of a country in which elements from different approaches have been brought together to form a rich and balanced technology education curriculum.

## IMPLICATIONS FOR TEACHING ABOUT TECHNOLOGY

In this final section, some practical implications for teaching about technology will be presented. After all, teachers may wonder what the relevance for these philosophical reflections could be for them. Philosophy seems to be remote from what they do anyway, and why would that be different for philosophy of technology? In the preceding sections, some hints for implications have already been given, but they will be elaborated further here. Teachers make day-to-day decisions continuously.

Often the arguments leading to choices have a fairly pragmatic character: what is feasible in the classroom, what would keep pupils involved, etcetera. Those are all valid arguments, but it would be valuable if arguments coming from a philosophy of technology knowledge base would also play a part in these decisions.

What philosophy of technology can do is give teachers themselves a good understanding of the nature of technology. But it is also important that pupils get a good understanding of the nature of technology. In fact, all practical choices concerning activities in classes should be made so that all the activities somehow add up to a realistic and valid image of what technology is. That means that ideally in every activity pupils are stimulated to think about the nature of the artefacts they design, make and/or use, about the knowledge that they draw from in order to do that, about the nature of the process they go through, and the values that are involved. Of course, not each and every project needs to be burdened with such a load, but the fourfold way of looking at technology (artefacts, knowledge, processes and values) can serve as a general guideline in the background for teachers to make decisions about what will be done in classes. For instance, a teacher preparing a project in which pupils will design a simple vehicle that travels a certain distance using energy from an elastic band, could introduce this activity to pupils in such a way that they have to think about how to choose the vehicles properties so that function and physical realisation are complementary. Furthermore, they have to consider what knowledge from physics might be useful, as well as knowledge from technology (e.g., about transmissions). Thirdly, they are challenged to plan their ‘design and make’ process while considering what steps are usually in a design process and what way to go would be the best in this particular case. Finally, they can be challenged to think about values like being economical with materials, and if the project is extended a bit to include some more theoretical work on real vehicles, they can reflect on values like costs, safety, aesthetical values, etcetera. By preparing the project in this way, the teacher turns the fourfold way of looking at technology from philosophy into a practical guideline.

In the example above, the emphasis is on the design and make process and in the extended version also social aspects are considered. The list of different approaches to technology education can inspire teachers to opt for a richer activity, in which elements from other approaches are also present. Pupils could also explore the engineering concepts of systems, optimization, and resources in doing this project. They may also be stimulated to think about how the vehicles they design could be produced in a factory. In doing the project, specific opportunities for acquiring key competencies could be built in, for instance, by having the students present the end product in a well thought through manner, or have them pay explicit attention to a good division of labour in the group. This way the values of the various approaches are combined and rich learning opportunities emerge.

Apart from these types of planning activities, there are more practical decisions to be made. Let us think about the availability of resources in the classroom. What consequences may philosophy of technology have for that? It would be nice if the fourfold way of looking at technology would be mirrored in the classroom or lab.

That would mean that artefacts would be available for pupils to explore and so develop an understanding of their dual nature. It would also mean that knowledge sources would be available for them to consult and involve in their work. It would mean that space for different types of activities would be available (for designing, making and testing/using/evaluating). It would also mean that values are somehow present. That sounds rather abstract, but there are various ways of incorporating values in a practical way. Safety and sustainability as values in technology can be illustrated by posters, for instance. Maybe there are opportunities to watch DVDs or video clips online about the social and human aspects of technology. One attractive opportunity for that is to use science fiction movies and let pupils reflect about whether or not they would like to live in the world as it is presented in those movies.

Finally, I would like to mention decisions regarding assessment of pupils. Quite often, what is assessed is fairly limited. In many cases the practical abilities of the pupils will be assessed, and perhaps some paper-and-pencil tests will be used to check their understanding of theory. But there is much more to be assessed if we use the philosophy of technology structure. What is not assessed, for instance, is the pupils attitude towards technology and their concept of it. It would be worthwhile to assess those, too. This need not necessarily be done by fancy questionnaires or other formal instruments but, perhaps, could be done better by talking about it with the pupils. Teachers could plan reflective moments in class in which individual pupils are invited to express their image of and attitude towards technology and this can give rise to a discussion, but at the same time gives the teacher an impression of the progress (or lack of that in the worst case) of the pupils' overall thinking about technology.

## CONCLUSIONS

In this chapter we have seen how philosophical reflection on technology can take different forms. One can look at technology as a set of artefacts, as a knowledge domain, as a series of activities and as an aspect of our human being in which, by definition, values play an important part. We have also seen how each of these four modes of reflection on technology has implications for technology education. Finally, we have seen how different approaches to technology education can emphasize different elements of these four modes and how more recent developments in technology education have brought about combinations of approaches that result in a curriculum that contains the various modes of reflection on technology. Although any attempt to develop a set of standards or a curriculum framework for international use has been unsuccessful, it is to be expected that the internationalisation of technology education will continue and gradually make technology education curricula look more similar than in the past when countries usually had a rather outspoken preference for a particular aspect of technology. This will certainly be to the benefit of technology education in general. It will cause an increased interest in exchanging materials and making joint efforts to develop curricula and do research. In the end teachers and pupils will have the ultimate benefit of this development.

That way technology education makes its own contribution to the literacy that is needed for today's world.

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