Technology in Compulsory School – Why? What? How?

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Abstract

With this article, we wish to make a contribution to the ongoing debate about the nature of technological literacy, by sharing our views of what goals are important to strive for within technology as a school subject in compulsory school, six to fifteen-year old pupils, as well as our ideas concerning what kinds of knowledge the pupils should be enabled to acquire.

The goal is to develop the pupils' ability to work in projects, to work with problem solving and to make sure that the pupils gain a technological awareness about the technology of their local environment, and to improve their ability to communicate by means of different presentation techniques.

The capabilities the pupils should be able to acquire within the technology subject are tied to a concrete content. We discuss the issue of learning material and what ways of working are proper to projects dealing with problem solving. In this discussion we are using the concept 'shaping of technology'. In the process of shaping within the technology subject at school, meaning is created, and both theory and practice are interwoven in this process. The shaping process in technology education is similar to design methods of engineers, industrial designers and in particular architects. However, unlike them, pupils will not discover, create or develop useful technical products but will instead gain insight and knowledge about the origin and function of technology and its importance to people, nature and society.

Key words

compulsory school, educational content, technological literacy, technological awareness, capabilities, shaping of technology

Introduction

Course curricula for technology in compulsory school in several countries, for example in Poland, New Zealand and Sweden, display a clear connection between technology and human culture, where the aim of the education in technology is to prepare the pupils for a life in a technological civilization. Moreover, as a school subject technology has a clear profile in relation to both the natural and the social sciences, and it is also clearly distinguished from the earlier tradition of more practically oriented education. At the same time, the subject contains elements from all of these areas, but the knowledge aimed at is, nonetheless, different. That is to say, the technology subject is today, in several countries, largely a subject centered on literacy in which different kinds of knowledge, both practical and theoretical, are taken into account, accompanied by an increased focus on the consequences of the encounter between the individual, technology, society and nature. Both nationally in Sweden and internationally, there is today an ongoing debate about the nature of technological literacy. In an International Conference on Design and Technology Educational Research, PATT 18, Glasgow 2007, researchers from different countries discussed technological literacy and education and the need to engage in a new literacy, a literacy that will enable us to reflect upon our new technological life world (e.g. Feenberg, 2006; de Vries, 2006; McCormick, 2006; Keirl, 2006). But also other pressure groups are today discussing what competences are important to develop. For example this thought-provoking quote from the writing *Foretagsamma skolan*, SAF (Risberg & Madsén, 1997: 21), regarding what one in the industry in Sweden regards as central to develop in pupils within compulsory school:

> *A school that shall create an enterprising spirit as well as conditions for lifelong learning has to be based upon "problems that seek knowledge"! If the school is to provide its pupils with a human competence that grants to the individual an ability to cope with the role as a citizen in a complex society, this means that the school has to create situations where the pupils are able to develop this competence. Situations that provide conditions similar to those pertaining to life outside school. The task of the school will be to develop forms for supporting the pupils' efforts at taking hold of these situations.*

With this paper, we wish to make a contribution to this debate, by sharing our views of what goals are important to strive for within technology as a school subject in compulsory school, as well as our ideas concerning what kinds of knowledge pupils should be enabled to acquire. In addition, we discuss the consequences of our views as regards what educational content and methods are best suited to make pupils able to attain this knowledge. The paper is written in the Swedish context where the course curriculum leaves issues concerning content and working methods to the individual teachers to resolve (Skolverket, 2000).

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Goals for technology as a subject in compulsory school

An important goal for the technology subject in compulsory school is, according to us, that of promoting a technological awareness. This awareness should involve specifically technological knowledge, such as that concerning the construction and effects of artifacts, as well as their function in technical systems. Further, it also includes knowledge of how technology has developed over time, as well as of the interplay between technology, mankind, society and nature. A technological awareness equally involves an understanding of technological concepts associated with the technology selected for study, and is central to the understanding of our technological environment. During the time in compulsory school, different technological areas are examined in our highly industrialized society, for example areas like transportation, communication, housing, bio-technology, energy and ergonomics. So in this respect at least, one may say that the understanding grows and is expanded naturally.

Another goal for the technology subject is, in our view, that pupils should improve their capability to create knowledge. That is to say, the pupils should develop both out of their own capabilities and in relation to a social as well as a working life marked by constant change. During the time spent in compulsory school, however, the pupils are in need of support in order to develop their capability for knowledge. Working in a way that is oriented towards projects is a tool for learning something new, or in a new way (see e.g. Skrøvset & Lund, 2000; Albertsson, 2002). When working in projects on aspects of problem solving, where no ready-made solutions are given, the pupil is able to develop his or her creativity. This is a kind of competence that is demanded in adult and working life, and it pre-supposes that one has a grasp of reality and is able to solve problems encountered in everyday life (Risberg & Madsén, 1997).

The fourth goal for technology as a school subject is, as we see it, that pupils should be given opportunities to develop their powers of communication with the help of various presentation techniques, such as sketches, images, models and computer programs, since these all constitute the language of technology. The powers in question are thus developed as the pupils are enhancing their awareness of our technological environment as well their capability of problem solving and of working in projects. In our view, technological literacy therefore concerns:

- technological awareness regarding various technical areas;
- ability to work with problem solving;
- ability to work on projects;
- ability to communicate one's thoughts and ideas with the help of various presentation techniques, such as speech, writing, sketches, images and models, both manually and digitally.

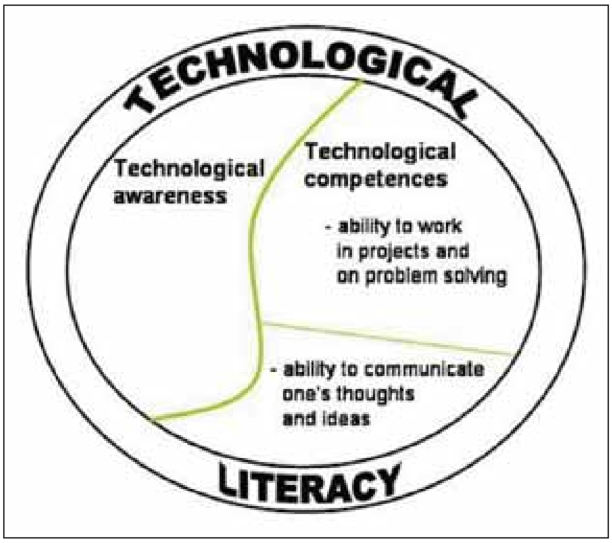

Figure 1. Different aspects of technological education

The different aspects of technological education that are emphasized as important (*Figure 1.*) should hopefully provide pupils with usable tools with respect to the future. In the next part, we clarify what kind of capabilities we have in mind.

Capabilities to be developed within the technology subject

Capabilities that are considered important, today, are that pupils should acquire more than just specialized knowledge, which is to say that they should also be able to put their knowledge into practice. They should learn how to learn and become familiar with different methods both within and in between different subject fields, at the same time they should also develop their social capacity (Risberg & Madsén, 1997; Skrøvset & Lund, 2000). The capabilities which today are emphasized as central, may, in our view, be developed in pupils during their time in compulsory school precisely within the technology subject, by virtue of its specific nature. In this way, education in technology promotes a technological mode of thinking in pupils.

Rosell (1990) distinguishes between three forms of thinking within engineering that are all necessary in order to attain this goal: rational thinking, innovative thinking and artistic thinking. Rosell writes that artistic thinking is the least accepted mode of thought in engineering, but that there still is an aesthetic dimension in technical creation. That is to say, technical creation has to involve a sense of the whole, of the interplay with man, with function, etc. This kind of sensitivity or thinking has its origin in art, not in science, and it is closely related to non-verbal, especially visual, thinking. In contrast to the distinction between three forms of thinking suggested by Rosell, Sternberg (2000) divides thought into an analytic capacity (strategies for solving recognized problems), a creative capacity (strategies for new problems; for creation and invention) and a practical ability (strategies for application and action). Franus (2000) has in his research discovered that technological thinking appears in four forms that do not take place according to any chronological order but occur simultaneously in connection with technical problem solving:

Practical thinking
- Simple routine actions – governed by thought, e.g. handling tools, simple manufacturing.
- Manipulative thinking – mounting and dismantling of technical devices.
- Exploratory thinking – diagnoses, investigation of new products.

Visual thinking
- Reproductive thinking – e.g. when reading technical drawings.
- Creative thinking – in connection with projecting, construction work from simple sketch to drawing, models.

Intuitive thinking
- Improvement of existing constructions or creation of new ones, and thought-out forms of construction in the world of ideas.

Analysis/synthesis and conceptual thinking
- This mode of thought concerns systems of concepts or technical categories occurring in explanations, justifications as well as in the shaping of actions. This is both an analytic and a synthetic thinking directed toward structure, function, aesthetics and ethics.

The capabilities pupils should be able to acquire within the technology subject are tied to a concrete content. We will return to the issue of learning material below; first we would like to discuss what ways of working are proper to projects dealing with problem solving.

The methodology of project work – the way of working in engineering

Projects are the form of work characterizing the technical field in working life in addition to playing a central role in higher education. For this reason, it is important to introduce project work in compulsory schooling, so that the pupils' aptitude for this kind of work can be prepared for and developed.

To work in projects involves choosing, either collectively or individually but in collaboration with others, an area, delineating it and formulating problems related to it, which then are investigated and elaborated with the help of different sources of knowledge. The working process eventually terminates in an end product that is evaluated together with the entire process. Projects are a usable way of working in connection with technical problem solving, but requires careful preparation and competent guidance. In working life, projects concerning a specific technical development are often realized in two steps. That is to say, the process from idea to finished product encompasses both a projective and a productive part. Projection, the first step in the process, leads from the formulation of the problem, through analysis, the conceiving of ideas and sketches, to a technical drawing and visualizations of different kinds. Production, the second step in the technical development, translates the technical drawing issuing from the projecting process to a technical process that results in a finished product or innovation. The first step, projection, can be illustrated by reference to the architect's creative work that results in a model and a technical drawing of a house, or to the industrial designer's drawing and model of, for example, a car. In the second step, the production, the builder or civil engineer can, in virtue of his special knowledge, transform the architect's proposal into construction drawings and, eventually, into the erection of houses. By comparison, the engineers at the car factory make detailed construction and production drawings in order then to design prototypes for, and therewith to make possible the manufacturing of, cars.

With respect to the technology subject in compulsory school, the first step, that is, the projective process, is in our view particularly interesting. The process of shaping in technology education is reminiscent of the modeling way of working, employed by the industrial designer and above all by the architect within the projective part. The architect does not himself build the house, but in the models and technical drawings delivered by him for future production, there is much knowledge embedded.

> *A designer makes things. Sometimes he makes the final product; more often, he makes a representation – a plan, program, or image – of an artifact to be constructed by others…. He shapes the situation (Schön, 1987, p. 78).*

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Unlike the architect, however, the pupils' projects will not result in an actual process of production; instead, they will, with the help of analyses from different perspectives as well as by means of physical models, sketches, simulations, documentation, etc., reach an insight into the genesis and function of technology, as well as of its effects on humans, nature and our society.

Shaping of technology – tools for technological awareness

Shaping of technology refers to the visualization or presentation of a specific technology familiar from everyday life for the purpose of understanding it. In the process of shaping within the technology subject at school, meaning is created, and both theory and practice are interwoven in this process. Moreover, it gathers different perspectives and situates them within an everyday context. The model is the working method characteristic of the industrial designer and above all by the architect, including all the phases belonging to the process of problem solving: Formulation of the assignment, information search, proposals for solutions in the form of sketches, models, etc., and finally evaluation. The philosophical foundation for this way of thinking with respect to 'shaping of technology' is derived from Heidegger's ideas concerning the nature of technology and from Dewey's conception of teaching and learning (Heidegger, 1974; 1968; Dewey 1916; 1997, see also Blomdahl 2005; 2006).

The steps involved in the realization of project works may be summarized in the following way: You set out from some specific technology present in everyday life, which means that the pupils' experiences and commitment make up the point of departure for the choice of product, production process or technical system (*the place with different products, production processes and technical systems)*. By using technology available in the near environment it also becomes natural to use the local environment as a learning arena. However, the choice between different products, processes or technical systems that the teachers and pupils have to make must take into account both the age of the pupils and local conditions in general. *The process of technology shaping* may be described as a chain of phases that in principle is contained in every project: *Formulation of the assignment, Analysis, Visualization/construction, Evaluation/reflection*. These phases also in effect constitute the basis for the processes of problem solving occurring in working life, as has also been indicated above.

Formulation of the assignment

The starting point for technical projects in working life consists in describing and clarifying the assignment in broad outline, as well as circumscribing and demarcating it. Also in our view, each project in the technology subject should begin with a formulation of the assignment, that is, in connection with the project start, accompanied by a background description that explains and justifies the envisaged project. In connection with teaching, it is common to use the word 'problem' or 'problem based task', but these expressions are associated with difficulties or troubles. The expression 'problem solving' may also give rise to the idea that there is only one solution. By contrast, an assignment is a formulation that indicates one way or one direction of action, which allows for different kinds of solutions. The pupils are to carry out a defined assignment or to take care of some requirements that have been pointed out; these may concern improvements of existing technical systems or products, creation of original ideas, or simply the development of some kind of technology or other.

To create exciting assignments is maybe the most important as well as the most difficult aspect of technology teaching. The formulation of the assignment is of particular importance, since it circumscribes, clarifies and delimits the scope of the assignment. Instead of just stating that the project should be about boats, the formulation can take the form of questions, such as 'How is a motor boat constructed?' 'What did boats look like in the past?' 'What different kinds of boats are there and what function do they have?' 'What significance to man have boats had generally?' 'How does one make a scale model of a ship?' Questions like these show more clearly what the project is about and may, therefore, animate the project and make the pupils committed. We think that assignments always should be formulated in a dialogue with the pupils. Irrespective of what kinds of assignments and approaches are chosen, they must heighten the pupils' awareness of their technical environment and in this way make the teaching more authentic. Important sources in connection with the introduction of assignments may be, for example, newspapers with articles on current news in the technical area, books for younger children, incidents in the local environment, studies on products capable of improvement, etc. In other words, what is crucial here is to benefit from the circumstances and to take into account what has attracted the pupils' attention. This is not always possible, however, and the teacher may also for his or her own part create situations considered appropriate and in this way encourage pupils to record things worthy of analysis and shaping.

Together with pupils a plan for the project is made, that is, an overview of available material, information, tools, time limits, report forms and criteria for evaluation. It is on the basis of this overview that the pupils should work in their respective projects.

The role as teacher is significant and it will, evidently, vary in accordance with the way the project is introduced, which in its turn is dependent upon the age of the pupils as well as upon the context in general. When it comes to realizing technical projects in lower grades, six to eleven year old pupils, where the pupils for obvious reasons are not yet capable of this way of working to the same degree, the teacher's role is different. Here, the teacher is more of a co-constructor who within the project explores the environment, in this case the technical environment, together with the pupils (Dahlberg et. al., 2002). The teacher supervises the entire project, and eventually, small assignments are formulated together with the pupils within the project's framework, so that, at the end of their work, several projects have been carried out that have increased the pupils' awareness of the technology that originally was singled out for study.

Analysis

Within the analytic phase, the architect and the industrial designer all experiment with different methods in order to be able to solve their problems. This is an approach that lets them assess the complexity of their problems and acquire knowledge from different perspectives.
In contrast to the methodology used in engineering, which aims to solve a real technical problem, the aim of the analytic phase in technology education is to provide pupils with a technological awareness with respect to a few technical areas, at the same time they should be enabled to understand the methodology of engineering employed in technical problem solving. But how exactly does the teacher, together with the pupils, analyze the assignments? This is something that may be determined by the following perspectives, which have the function of directing the analysis with a view to situating the particular kind of technology one is working on:

- a perspective centering on the history of development, which may grant to the pupils an opportunity to understand different driving forces behind technological development;
- a system and component-based perspective, where studies on single technical solutions and their place within larger systems may give the pupils the opportunity to acquire important insights into the specific character and conditions of the technology selected;
- a functional perspective, which can provide the pupils with the opportunity to achieve an understanding of and familiarity with technical principles, namely, by studying and practically testing how the selected technology is construed and what function it has;
- a technological perspective including the aspect of lasting development. 'Lasting development' refers to an appropriate use of technique, namely, to improve, recycle, be economical with resources, material and energy. In the analysis, one can throw light on difficulties and possibilities connected with technical solutions, conflicts of interests, altered living conditions and economic consequences;
- a perspective centering on technology, man and the society. In order to understand the role and meaning of technology, the interplay between human needs and technology has to be elucidated. This perspective throws light on the consequences and effects of the use of some specific kind of technology as far as both the individual and the society is concerned, and with respect to both security aspects and ergonomics.

These perspectives are guidelines. In the analytic phase, the teacher may of course together with the pupils use other approaches to the analysis of the assignment in question. The analytic phase will, thus, take on different forms depending upon the assignment, age of pupils and the context, and it may involve, for example, educational visits, briefings by the teacher, interviews with people within the selected area, collection of data, films, practical tests in the form of functional models which should make understanding easier for the pupils, practice in sketch and model techniques which later should be used by the pupils in their own work.

Visualization/construction

Visualization in the form of sketches/drawings and physical models works as a synthesis in the engineering methodology since it makes visible the understanding one has acquired after the analysis. In the process of assignment formulation and analysis that one has had to carry out in order to be able to solve the problem, these sketches and models are the visible evidence of the understanding that has been achieved. This is, in other words, a form of learning. The third phase in the shaping process within the technology subject consists in visualization/construction and is, as in the case of the engineering methodology, a synthesis showing the pupils' understanding by means of sketches, descriptions, models, documentation and simulations. And when the pupil's understanding is made visible, the teacher also gets a foundation for evaluating the pupil's way of making experiences.

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Sketches may help the pupils to specify the problem and they may also form a kind of basic material for dialogue and discussion within the process of problem solving. Moreover, the pupils should be granted the possibility to develop their capabilities for making sketches and of converting their thoughts into two-dimensional images (Rosell, 1990).

The model materializes thought; it is about thinking in action. Rosell (1990) writes that a simple paper model is easier to comprehend than the most advanced two-dimensional illustration, and it immediately reveals such things that do not work in practice. To be sure, the material used in the model does not correspond with reality, but an understanding of reality is nonetheless contained in the model. This kind of model is a useful tool for displaying one's understanding and is therefore usable in technology education. Another kind of model is clay models. These may be used in order to reveal shapes in sculpture. Clay as material for models is used in the car industry, among other areas, but it may profitably be used within the practice of technology education. Here we have in mind above all the lower grades in compulsory school, since clay is easy to work with, can be painted, be covered with foil and be combined with other materials. A third kind of model is the so-called functional models that may be used to investigate and to show one's understanding of certain functions. Finally, we would like to mention simplified, basic models, such as models of bus line and subway systems. These models may be usable in technology education, namely, when the task is to understand technical systems or production processes. Today there are also computer programs that are easy to use for the pupils in compulsory school, namely as tools for visualizing their understanding.

In one respect, all technical projects are alike, namely, in that they are all documented in a written report. The report is a kind of summary of what has been done. It gives the writer an opportunity to develop his or her thinking in different ways, to practice his or her powers of expression, both linguistically and with the help of images. Since it centres on the aspect of understanding, this form should be usable in schools. The technical report may of course be of various kinds. In higher grades, twelve to fifteen year old pupils, the documentation can have the following content:

1. Choice and justification of the assignment.
2. Description of the analysis of the chosen assignment, maybe on the basis of questions originally collectively formulated as the project was introduced.
3. Sketches and descriptions of model production.
4. Documentation of one's own process of learning.
5. Information about content, references, etc.

In lower grades, six to eleven-year old pupils, the report may consist in a project book where all documentation made during the project is collected.

By using different kinds of visualization, the teacher enables the pupils to make use of different ways of learning. Different forms of visualization also make possible an analysis of the modern technology surrounding us, which is so complicated that it cannot be visualized by means of physical models. Instead, the analysis can be made with the help of interviews, educational visits, literature search and studies of manuals. In turn, the visualization of one's understanding can be made by means of written documentation, images, sketches, posters, etc. Visualization after the project work has been accomplished can also assume the form of exhibitions, oral presentations to one's classmates, other classes, parents, invited guests, etc.

Evaluation/reflection

Reflection in connection with shaping of technology is of great importance for both the process and the result, since it makes up a central element in all learning. It makes possible reflective experiences on the part of the pupils. Here is embedded a challenge for the teacher in his or her practice at school, namely, to make room for common opportunities for reflection. When introducing a project or an assignment, the pupils must, within the project's framework, be given clear instructions. It is in the dialogue with the pupils that the teacher can make them clarify their thoughts, which will help them move forward. Common opportunities for reflection during the work also enable the pupils to make reflective experiences. The problems are discussed collectively and different proposals for solutions are presented. In this way, the pupils are given tools to handle problems that have arisen or that may arise in the future. Here, the pupils' own experiences are used as resources for other pupils who may encounter problems of a similar kind. Previous research shows that the challenge for the teacher is above all to make room for common meeting places, that is, to have in one's pedagogical practice opportunities for common meetings and discussions (see e.g. Dysthe, 1993; Svärdemo Åberg, 2004; Blomdahl, 2007). Interaction and communication between teachers and pupils, or just between the pupils by themselves, give the pupils an opportunity to benefit from both the teacher's and the classmates' knowledge. Thereby, they get the chance to be exposed to conflicting views. Brown (1997) has together with her research group pointed out ways of working where one concretely, with the help of small groups, can create meeting places for reflection and cooperative learning (see also Project Zero & Reggio Children, 2001). However, taking time to have joint conversations after the project has been finished, so that the pupils can gather all their impressions, and emphasizing some aspects that have been significant and that may be of use in future projects, is also central to the pupils' ability to learn from experiences. Accordingly, reflection is involved in the entire process, that is, both before, during and after the finished work, at that point in the form of evaluation. When evaluating, the pupils can develop their capacity to reflect on their own way of learning. Finally, reflective experiences are brought from the shaping process that has been carried through, to the next project.

A didactic model for teaching in technology

When the concept of place is situated within the context of technology shaping, a model for education in technology may look like this:

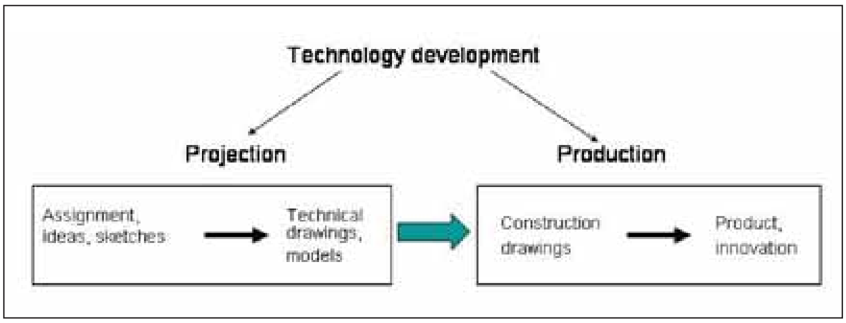

Figure 2. A didactic model for teaching in technology

From a didactic perspective, this model is of a kind that has been described in terms of 'negotiating the curriculum', or 'school-based curriculum development', that is, a model according to which teachers and pupils collectively negotiate about the didactic disposition of a working field or an assignment (see Arfwedson, 2003). The purpose of such negotiation is to make the pupils take a greater amount of responsibility for their learning. It should also be made clear, if the didactic model is to give a fair picture of technology shaping, that the different phases included in it do not illustrate any 'step-by-step' action. The danger of this kind of simplified model is that it can mislead the reader into believing that shaping of technology is a linear process, when it in fact consists in a kind of oscillation between analysis, visualization/ construction and reflection. In a way similar to the approach characteristic of both the architect and the industrial designer, it concerns how to circumscribe the complexity and to gain knowledge of problems from different perspectives in order to solve them. The phases of the shaping process are thus included in the methodology that is used in professional construction work in our society today, albeit in a simplified form when converted into school practice.

Technological awareness is something that evolves over time in projects within different technological fields. Depending upon what stage in compulsory school the pupil has reached, the projects assume different forms. But the goal is the same, that is, to develop the pupils' ability to work on projects and to make sure that the pupils gain a technological awareness about the technology of their local environment, and to improve their ability to communicate by means of different presentation techniques.

The learning material in technology education

The choice of learning material for technology education takes its point of departure from, and should occur in interaction with, the reality both in and outside school. The place with its technical environment consisting in technical systems, production processes and products, makes up the learning material in technology education. By using the place as learning material, the teacher provides the pupils with the opportunity to become familiar with and to gain a more thorough understanding of various parts of the complex technical scenery puzzle. The simile with the puzzle should suggest that the teacher always works with different aspects of technology during the years in compulsory school.

Understanding is something that evolves over time, as one is granted the opportunity of a variety of acts of understanding. If the teacher continues to work with different parts of the technical scenery puzzle, then this will enhance the pupils' understanding of the technology surrounding them. Choosing learning material in this way also lets the teacher set out from the pupils' questions and reflections on the technical surroundings, as well as to concretely use the local environment in the teaching, for example by means of educational visits, etc.

The choice of learning material from the local environment also gives opportunities for thematic work where different subjects to some extent are integrated in the projects. In this way, the possibilities of understanding are extended. In a similar way the technology subject can be part of the project works within other school subjects. Setting out from the near environment and in general from something relevant to the pupils' situation, instead of taking one's departure from a knowledge base pertaining to some particular school subject, makes possible a more holistic and penetrating reflection on the chosen learning material. Choosing learning material in this way, however, requires a capacity for collective projection and documentation on the part of the teachers. It also presupposes a well-considered idea concerning what kind capabilities one wants the pupils to develop within a given subject.

Irrespective of what kind of learning material the teacher chooses to work with, there are some specific and basic content components that have to be fulfilled, otherwise the teaching will not be about technology. These are *technical information, knowledge of material, energy and documentation*.

Technical information means that the pupil should have the requisite knowledge of existing tools and machines at school, and be able to identify technical symbols and drawings, have the requisite knowledge of technical principles such as mechanisms, electrical and electronic circuits, solidity, etc., in order to gain an understanding of the function and structure of the chosen technology, as well as to be able to interpret information contained in product declarations, to know risks and dangers connected with technical devices and to be familiar with common technical professions. Technical information may be regarded as a resource in connection with the analysis out of different perspectives.

Knowledge of material means that the pupil should be familiar with common materials as regards their external as well as internal features, their area of use, and also with the way in which they are joined together and recycled.

Energy with its forms; storage, transformation, transportation and use in connection with steering and regulation together make up the basis for every kind of technical comportment and are consequently involved in every kind of learning material you choose to work with.

Documentation displays the entire learning process from the formulation of the assignment, over its analysis and different forms of visualization, to the reflection/evaluation of the technology that has been examined. As noted above, the documentation consists in sketches, models, simulations, written documentation, etc.

Mastering the concepts associated with each technological area is also central and makes up one aspect of the acquisition of a technological awareness. By working with shaping of technology, the pupils are granted the opportunity to conquer concepts within different fields of technology, both by practical tests and by means of more theoretical ways of working. From these areas the teacher may, together with the pupils, select particular products, production processes or technical systems.

Products

One way to work with technology is, as has been shown above, by setting out from a product the pupils encounter in everyday life and then analyze it. Such an analysis may give them a possibility to understand the function of the product's components, the choice of material, design, etc. It is important, however, that the product in question is examined from various perspectives so that it is put in context.

Production processes

Production processes concern the way in which raw material is transformed into finished products. The aim is to provide the pupils with an understanding of how humans make use of nature, as well as of the technology involved in production, and of how the production work is organized and how it affects people, society and nature. At this stage, one may also address questions concerning economic powers governing the production.

Eventually, the pupils will themselves become consumers. By studying production processes the pupils gain an insight into the way in which nature today is exploited with respect to its resources, and therewith also into the nature of lasting development, which is relevant to the individual pupil's own mode of acting both as a consumer and as a member of the society who can take part in the public debate on these questions.

Technical systems

In connection with teaching on technical systems, there are some central keywords to emphasize: input, process, output, feed-back coupling, sensitivity. Other concepts that render technical systems comprehensible are dynamics, steering and regulating. The keywords are universal and possible to use in order to understand different kinds of technical systems, but may also be used to clarify the nature of social organizations.

By studying technical systems in the local environment in compulsory school, one grants to the pupils the opportunity to gain an understanding of the technical reality they live in, for example the apartment with water and drainage, light, heating and cold, but also waste disposal, drain clearing, traffic systems and communication of all different sorts. Hence, the aim is that the pupils should develop a *technological awareness* of how society is constructed in systems. Looking at technology with a bird's eye view and moving between different levels within the systems makes it possible for the pupil to understand how large systems have sub-systems, that the product studied in itself is a system, at the same time as it is a component in a larger system.

One way of working on technical systems is to direct the education in such a way that all stages in a technical system are made visible, that is, from the requirements, over the process of design and production with the available resources, packing, transportation, storage, and all the way to the consumer.

Another approach is to take the departure from large technical systems, e.g. transportation, and to try to make the pupils discern the structure of the system, such as transportation by land and sea, by air and in space. These may then be divided into sub-systems; e.g. transportation at land may be divided into buses, trains, cars, bicycles, etc., but also into roads, petrol stations, repair shops, garages, etc. The car may in its turn contain drive and fuel systems, an exhaust gas system, an electronic system, a cooler and a steering system. Then one may choose a particular subsystem or component that one wishes to understand more thoroughly and thus analyze it on the basis of several perspectives.

Today, our everyday life largely consists in handling complicated electronic devices. In order to understand them, systematic thinking is useful in connection with teaching. By paying attention to totalities and parts with various functions, rather than to functions of the smallest components regarded in isolation, and by trying to discern the interplay between these parts, pupils are able to get an overview. The parts may be compared to black boxes with different functions that together form a whole, which it is possible for pupils to comprehend. Such a way of thinking about electronics would make possible to deal with, at the end of the time in compulsory school, electronic systems with IC circuits and the inputs and outputs of the processor for the purpose of steering simpler mechanical models.

Finally, it is important that the teacher delimits the project works so that they become manageable and interesting for the pupils, otherwise the work on technology runs the risk of being regarded as difficult and too comprehensive. Technical projects may in other words make use of the learning material in various degrees, and, accordingly, be finished in a few days as well as take up an entire semester. We, however, believe that one should work on projects during a longer period of time rather than having a great amount of smaller projects. This is also something that Lindström (1999; 2002) claims in his research, which centers on the importance of granting to the pupils both time and opportunity to become familiar with and to finish their work, as well as of having an ongoing dialogue on the work during the working period. Lindström writes that the risk at school is that too much is put into the schedule so that both the teaching and the knowledge become too fragmented. The motto on technology in compulsory school should be: less and more penetrating work, where the pupils are able to attain a technological awareness and an ability to both communicate and manage their learning process, rather than to treat too comprehensive and complicated systems in an abstract and superficial way within a short time.

Summary

The aim of this article has been on our part to make a contribution to the discussion about teaching and learning technological literacy in the classroom. We have shared our views concerning content and ways of working with respect to the technology subject and what capabilities the subject should help to develop in the pupils today.
Our ideas about what technological literacy could be today, what content and working methods as well as what capabilities to concentrate on, are of cause coloured by the fact that we both are living in a Swedish context. Can our ideas be of interest in other countries when discussing the need to engage in a new literacy that will enable us to reflect upon our new technological life world? We hope so.

References

Albertsson, Sten (2002). ABC: *projektarbete*. Bonnier Utbildning, Stockholm.

Arfwedson, Gerd (2003). 'Curriculum as a Teacher Problem'. In E. Forsberg (ed.) *Skolan och tusenårsskiftet: en vänbok till Ulf P. Lundgren*. Research Reports 2003:2. Uppsala university, STEP, Department of Teacher Education, Uppsala, 189-204.

Blomdahl, Eva (2005). 'Towards a Philosophy of Technology Education Based on Heidegger and Dewey'. In L. Lindström (ed), *Technology Education in New Perspectives. Research, Assessment and Curriculum Development*. HLS Förlag, Stockholm, 103-126.

Blomdahl, Eva (2006). 'Att undervisa i teknik – försök till en undervisningsfilosofi utifrån Heidegger och Dewey'. *Nordina*, nr. 3, 42-55.

RESEARCH

Blomdahl, Eva (2007). *Teknik i skolan: en studie av teknikundervisning för yngre skolbarn*. HLS Förlag, Stockholm.

Brown, Anne (1997). 'Transforming Schools into Communities of Thinking and Learning. About Serious Matters'. *The American Psychologist: Journal of the American psychological association*, 52, 4, 399-413.

Dahlberg, Gunilla., Moss, Peter & Pence, Alan (2002). *Från kvalitet till meningsskapande: postmoderna perspektiv – exemplet förskolan*, övers. G. Arfwedson & G. Arfwedson. HLS Förlag, Stockholm.

De Vries, M.J. (2006).'Technological Knowledge and Artifacts: An Analytical View'. In J.R. Dakers (ed.) *Defining Technological Literacy: Towards an Epistemological Framework*. New York: Palgrave MacMillian.

Dewey, John (1916). *Democracy and Education: An Introduction to the Philosophy of Education*. The Free Press, Macmillan Publishing Co, New York.

Dewey, John (1997). *Demokrati och Utbildning*, övers. N. Sjödén. Bokförlaget Daidalos AB, Göteborg.

Dysthe, Olga (1993). *Writing and Talking to Learn. A theory-based, interpretive study in three classrooms in the USA and Norway*. Rapport nr. 1 1993 i APPUs skriftserie. University of Tromsø, Tromsø.

Feenberg, A. (2006). 'What Is Philosophy of Technology?' In J.R. Dakers (ed.) *Defining Technological Literacy: Towards an Epistemological Framework*. New York: Palgrave MacMillian.

Franus, Edward (2000). *Wielkie funkcje technicznego intelektu*. Wydawnictwo Uniwersytetu Jagiellonskiego, Krakow.

Heidegger, Martin (1968). 'Lecture 1'. In *What is called thinking*? övers. J. G. Gray. Harper & Row Publishers Inc., New York.

Heidegger, Martin (1974). *Teknikens väsen och andra uppsatser*, övers. R. Matz. Rabén & Sjögren, Stockholm.

Keirl, S. (2006). 'Ethical Technological literacy as Democratic Curriculum Keystone'. In J.R. Dakers (ed.) *Defining Technological Literacy: Towards an Epistemological Framework*. New York: Palgrave MacMillian.

Lindström, Lars., Ulriksson, Leif & Elsner, Catharina (1999). *Utvärdering av skolan 1998 avseende läroplanens mål (US 98). Portföljvärdering av elevers skapande i bild*. Skolverket/ Liber Distribution, Stockholm.
Lindström, Lars (2002). 'Produkt- och processvärdering i skapande verksamhet'. In Skolverket (ed.) *Att bedöma eller döma: tio artiklar om bedömning och betygssättning*. Skolverket/Liber Distribution, Stockholm, 109-124.

McCormick. R. (2006). 'Technology and Knowledge: Contributions from Learning Theories'. In J.R. Dakers (ed.) *Defining Technological Literacy: Towards an Epistemological Framework*. New York: Palgrave MacMillian.

Project Zero & Reggio Children (2001). *Making learning visible: children as individual and group learners*. Reggio Children, Reggio Emilia.

Risberg, Ola & Madsén, Torsten (1997). *Företag som läromedel*. Svenska Arbetsgivare föreningen, Stockholm, www.svensktnaringsliv.se

Rosell, Gustaf (1990). *Anteckningar om designprocessen*. Kungl. Tekniska högskolan, Stockholm.

Schön, Donald (1983). *The reflective practitioner. How professionals think in action*. New York: Basic Books.

Skrøvset, Siv & Lund, Torbjörn (2000). *Projektarbete i skolan*, övers. S. Andersson. Studentlitteratur, Lund.

Sternberg, Robert (2000). *Handbook of Intelligence*. Cambridge University Press, Cambridge.

SOU 1992:94. *Skola för bildning: betänkande av läroplanskommittén*. Utbildnings-departementet, Stockholm.

Svärdemo Åberg, Eva (2004). *Lärande genom möten: en studie av kommunikation mellan lärare och studerande i klassrumsmiljö och datorbaserad nätverksmiljö*. HLS Förlag, Stockholm.

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