Technology education in primary school in Sweden: A study of teachers views on teaching strategies and subject content.

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Introduction

Technology education in Sweden has been a mandatory subject in compulsory school since the mid-1980s. Its origins are in metal and wood working, but it has developed into an interdisciplinary subject that includes crafts, engineering science and the history of technology.[1][2] The current curriculum, introduced in 2011,[3] and current school law[4] allow teachers a great deal of freedom when designing teaching activities. The purpose of this paper is to describe how four different technology teachers organize their teaching, especially how hands-on workshop activities are used when teaching the varying contents of the subject.

The Swedish school system

Schooling is mandatory for all children in Sweden between the ages of seven and sixteen. The subjects studied during these nine years are described in the national curriculum,[3] which is mandatory. Each subject is described by an introductory text explaining its purpose, a set of skills that pupils are to develop through training in the subject in question, and a list of core content. The core content for the subject must be treated as a whole. Neither the curriculum nor school law regulates the teaching methods. As long as the pupils learn what they are supposed to learn, the schools' owners (the municipalities in most cases), the school boards, and the teachers are free to choose among different pedagogies and activities for teaching and learning. The subject descriptions in the curriculum are quite vague and open to interpretation. The contents of each subject do not have to be exactly the same in every school, as long as it follows the curriculum and is equally valuable.[4]

Apart from the national curriculum, the National Board for Education (*Skolverket*) also publishes booklets, films, and lists of advice for teachers on how to implement the curriculum. These are not legally binding, but nevertheless have high status among teachers and heads of schools.

The technology subject

Technology was introduced as a mandatory subject for all pupils in the 1980 curriculum. At this time technology was closely linked to the science subjects (biology, physics, and chemistry). In the curriculum, it was not clearly defined in what ways technology differed from the established science subjects, and in many schools it was lost among them. Many pupils were not even aware of having studied technology.[5] When the national curriculum was revised in 1994, technology became a subject separate from science, with a more explicit interdisciplinary nature. Now environmental issues are a part of the technology curriculum, together with the history of technology and related social issues. Unfortunately, this second introduction of the technology subject was also unsuccessful. Still, few teachers had adequate training. In many schools technology was assigned to teachers with training in either physics or crafts. This resulted in different versions of the subject with emphasis on either applied

natural science or metal shop work. It did not become the interdisciplinary subject that was intended.[6]

In the curriculum of 2011, the characteristics of the technology subject became clearer: "Teaching in technology should aim at helping the pupils to develop their technical expertise and technical awareness so that they can orient themselves and act in a technologically intensive world."[7] The abilities pupils are expected to develop are:

- identify and analyze technological solutions based on their appropriateness and function,

- identify problems and needs that can be solved by means of technology, and work out proposals for solutions,

- use the concepts and expressions of technology,

- assess the consequences of different technological choices for the individual, society, and the environment,

- analyze the driving forces of technological development and how technology has changed over time.[7]

The core content, according to the syllabus, should be studied for students to develop these abilities. It includes mechanics, materials, electronics, automatic control, the product development process, and technology's relation to science, to society at large and to the fine arts.[8][9] Also notable is the lack of computers and information technology in the technology subject. Apart from the Internet mentioned as an example of a large technological system, and digital sketches and drawings being listed as ways of documenting technical work,[10] nothing specifically related to ICT is explicitly mentioned.

In the Swedish elementary school students also take the art and crafts subjects. Both are mandatory and have different content than the technology subject. Accordingly wood, metal, and textile work are included in the crafts subject[11] and are not explicitly mentioned in the technology syllabus.

Aim and research questions
This pilot study is performed within a research project about teachers' work in technology education. The overall aim of the project is to extend the knowledge about how teachers plan and carry out their teaching in accordance with the technology syllabus. Special attention is paid to how the teaching strategies of technology have been influenced by methods traditionally used in science studies (excursions, laboratory exercises, etc.) and crafts (design and making activities, with a strong emphasis on the "making" part) and to what extent a tradition concerning technology in itself been established.

The specific research questions for this study are:

What similarities and dissimilarities in teaching strategies can be found when comparing statements from four teachers with different subject backgrounds who teach technology?

What view on the subject do teachers with different subject backgrounds express?

Previous research
Research that has been conducted nationally and internationally on the subject of technology often takes as its starting point the curriculum, teacher perspectives and definitions of technology.[12] In Sweden research focusing teaching and learning technology. Based on teachers' perspectives, Blomdahl,[13] Mattson,[14] and Bjurulf [15] discuss how technology is perceived and portrayed by teachers. Bjurulf focuses on how a teacher works with the technology subject and how the teachers' education is important for teaching structure and content. Bjurulf also mentions that classroom and group size affects the choice of content. All teachers in the Bjurulf study performed design and make tasks, but it was found that the tasks were handled in very different ways and that reflection for a deeper understanding by the students was lacking in some cases.

Blomdahl[13] shows that teachers' lack of knowledge about pupils' preconceptions can cause problems in planning and implementation classroom activities. Not knowing the past experiences of students has been found to be an uncertainty factor.

Mattson[14] discusses how teachers, student teachers, and pupils view technology. Her work shows that teachers need subject competence to give the pupils a clear objective of the teaching.

At the time of writing, it is legal, but not recommended, for Swedish teachers without training in a specific subject to teach it. Due to the lack of properly educated teachers, this is very common in the technology area. According to a study by the National Center for Technology in School (*Cetis*) published in 2012, 50 % of those who teach technology are not formally qualified to do so.[16] Hartell, Gumaelius and Svärdh[17] discuss the education of Swedish technology teachers and the implications if teachers not are trained specifically in technology. The results indicate a significant difference between teachers with training and those without training in technology education, in their perceptions of their ability to teach and assess technology. The findings indicate that when teaching technology, teachers with training in technology education use curriculum documents (both national and local) to a significantly greater extent than do those who lack such training. Hartell et al. also write that the pupils will benefit from goals and criteria that are transparent,[18] which is only possible if the teacher has a fundamental understanding of the specific subject domain, as well as knowledge about common misunderstandings that may occur when learning a specific subject. Activities that the teacher designs are based on knowledge of both the subject (subject matter) and knowledge in pedagogy. This knowledge as a whole can be referred to as Pedagogical Content Knowledge (PCK).[19 20 21 22] In an attempt to understand the nature of teachers' knowledge, Shulman[23 24] developed the concept of PCK to address the importance of integrating subject matter knowledge and specific pedagogy in teaching. Later research in PCK shows that teachers build PCK through a transformation of other fields of knowledge, such as subject knowledge, pedagogical knowledge, and knowledge about teaching context.[25]

Technology has been a mandatory subject in the Swedish compulsory school system for more than three decades. Nevertheless, in Sweden there is still no consensus regarding the content

and practice of the subject,[8][26] which has resulted in insecure teaching[27][28] and varying levels of knowledge among students.

Method
The study was conducted by interviewing four teachers about how they teach and about the content of their teaching. They all teach technology in years 7–9 (pupils aged 13–16). The teachers are all educated as technology teachers, but they have different backgrounds. Some are trained to teach science and/or mathematics. One of the teachers has a degree in engineering and worked as an engineer before becoming a teacher, and one of them is also trained in crafts.

Table 1: The respondents

Name (not real)	Gender	Subjects and educational background	Other
Adam	M	M.Sc. in Engineering, Qualified to teach mathematics, physics, chemistry, biology and technology. Teacher for 11 years	Subject 55 min/week (year 7–9 = approx. 95 h in total)
Bertil	M	Qualified to teach crafts, and technology. Teacher for 25 years, 7 years technology teacher	Subject 55min/week (year 7–9 = approx. 95 h in total)
Cesar	M	Qualified to teach mathematics, physics, chemistry, biology and technology.	Works in a school where a majority of pupils have Swedish as their second language Subject ¼ of Science time (7–9 = approx. 90 h in total)
Dagny	F	Qualified to teach physics, mathematics, and technology. Teacher for 14 years	Subject 1 h/week (7–9 = approx. 105 h in total)

All respondents have, to varying degrees, participated in "Boost for Technology" [29] (*Tekniklyftet*), a school development program hosted by the House of Science.[1]

The interviews were semi-structured in nature, and approximately followed a questionnaire (Appendix 1) with follow-up questions for clarification. The interviews were conducted at the participating teachers' respective workplaces. They lasted between 35 and 50 minutes and took place in October and November 2014. The respondents did not receive the questions in advance. The interviews were recorded live and were later transcribed by the authors. The analyze process including multiple readings of transcripts in search for themes and patterns in the respondents' statements.

The study follows the ethical rules imposed by the Swedish Ethical Review Act.[30]

Result

The interviews were descriptive about how the respondents' teaching is structured and how they plan and implement it. The findings are presented in relations to two areas:
1) pedagogical methods and 2) subject content.

1) Pedagogical methods

Major strategies

The respondents all think that designing and making are important parts of the technology subject, but have different views concerning the amount of time that should be spent on manual work. Dagny estimated that 70 % of the available time was spent constructing and building. Bertil described how everything can be learned through building things, and he seldom uses books or traditional lectures. He describes his teaching being mostly "practical," i.e., oriented towards designing and making, in year 9:

"I start with the technology in sixth grade, where it is about 60 per cent practical. In seventh grade, it is about the same and coming to eight grade, we will certainly be up to 80 per cent practically and in ninth grade, it is almost entirely practical. There is very little lecture teaching." (Bertil)

Cesar estimates that 70 % of his teaching in technology is practical and expresses:

"At this school, the theoretical part disappears into the practical part. It will be very much hands-on job, if you work with materials you have to have materials there to be able to feel and squeeze. It makes no sense to lecture on various material types and plastics and stuff. It runs together more here. Don't think I put a label on what we do. I say today we will do this, and if it is, say try and make a craft float for two minutes and then sink, we are first in the

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[1] House of Science is a science education center run by the KTH Royal Institute of Technology and Stockholm University. "Boost for Technology" project was financed through the European Social Fund (ESF), its purpose was to increase the quality of technology education and strengthen the abilities of technology teachers in the Stockholm region. Teachers who participated in Boost of Technology had over a two year period taken part in seminars, workshops, lectures, etc. on the subject of technology. They had discussed, planned and written their own schools' plans for working with the subject and how it should be taught.

theory and then tries to practically implement, operate and test and improve their solutions. They are probably related; they belong together."(Cesar)

Adam spends less than 50 % of his time on practical activities. Both Adam and Dagny say they start by introducing theory and then start a practical activity that is supposed to connect theory with practice. Adam says:

"First theories, then we turn to the practice of it. We have talked about triangular shaped forms, we've talked about corrugating, yet they seem to forget all while doing the practical part." (Adam)

All respondents participate in competition like First Lego League (FLL) and Future City (a competition planning a future city for grade 6 – 9) that take around 6 – 8 weeks to complete. Competitions, therefore constitutes a large part of technology education during that semester. Which abilities are trained and which parts of the core content are covered by participation in these competitions is not clear, but Dagny and Bertil says that much of the core content is covered.

Bertil did express thoughts about strategies for how to handle large projects taking this much time:

"W*hat I described to you, it is within this context, but I've tried other approaches that could provide better results. It is not based on that technology would have more time, but it is based on cooperation between different subjects.*" (Bertil)

Cesar does not attend the competitions with his class, even though his students do all the different parts of the competition. In this way, he saves some time and is a little freer in designing the competition.

Adam and Dagny seem to take methods and strategies for granted.

<u>Similarities with other subjects</u>
Three of the teachers also teach science (Adam, Cesar and Dagny). In science class they use an investigative approach where theory is tested in a laboratory experiment during one lesson. Activities of this kind are only used to a limited extent when teaching technology. Dagny and Adam each mention one short activity in technology class during which they test hypotheses in an experiment. Dagny works with stability of beams and exemplify it with clay. Adam talks about the stability of triangular shapes and corrugation. He demonstrates this by comparing the sturdiness of folded and flat papers. This is the only practical activity that resembles a science experiment. Cesar speaks of how he connects activities in technology with activities he does within the science class. In year 8 science, pupils study organic chemistry. Therefore, he includes a project about paper in chemistry class and paper manufacturing in technology.

Three of the respondent expressed that their teaching role is different when they teach technology compared with when they teach science. They look at themselves more as coaches

than as lecturers. Two of the teachers even say that the teachers' role in teaching technology is easier than in teaching other subjects.

<u>Classroom activities</u>
The teachers all plan projects that often take several weeks to complete when teaching technology. They talk about how they organize student work in the classroom. Dagny and Cesar mostly work with small groups of 2–4 pupils. Adam seldom uses groups in class. He wants the students to work mostly individually, as he feels that both assessment of group work is difficult and that pupils do not engage to the same extent in group activities.

Autonomous pupils, working with their projects, were put forward as the ideal by Bertil.

Two of the teachers describe how they feel constrained by the lack of proper equipment and rooms. They have to teach technology in regular classrooms or science labs, and bring tools and other gadgets that they need.

2) Subject content
All teachers described that theory usually is tied together with the practical exercise, but how they clarify specific knowledge in the area is not discussed. When the respondents describe areas that they consider theoretical, they talk about the history of technology, strength of materials, and technical drawing exercises, even though they have different thoughts about if drawing contains practical parts or not. These terms "theoretical" and "practical" are commonly used, but often with vague meaning.[31] They were used by the respondents to refer to activities rather than knowledge; "practical" meant "making" while "theoretical" meant something like "reading" or "listening to a lecture." The "practical" activities and related skills were seen as the core of the technology subject, and propositional knowledge should ideally function as a support for them, supposedly so that the knowledge of the concept is strengthened through its use.

All four respondents describe explicitly how they work with parts of the core content. Which abilities they try to train through the activities related to the content is not always obvious. However, all of the respondents say that they try to achieve students obtaining the expected abilities.

Adam, who has a background as an engineer, says that technology is about problem solving and expresses that he wants to teach the students more "industrial thinking": how you invent and how you already at an early stage in the design process try out and improve your product. Bertil, who has a background as craft teacher lets his pupils build a model airplane in one project. He mentions the connection to history of technology but not to the point of understanding technical development when he says:

"The purpose of building aircraft is not to explain transportation but to teach how to interpret technical drawings" (Bertil)

The respondents mention that the core content is huge. Cesar, the teacher who has many pupils with foreign backgrounds, claims that he has to exclude one third of the core contents

for the subject to fit the schedule. Bertil says:

"I make sure that tasks are such that the elements in the core content are included, or part of, I do not have time to do everything. It is only to realize, but I try to get as many parts as possible and then I choose tasks on that basis." (Bertil)

All teachers talk about time as a limiting factor. One of them finds that there is not enough time to do everything he feels is necessary to match the core content. The time for further reasoning and development of content is also restricted. Dagny says:

"Since we do not have time, but I would like, we stress to test the towers with as many books as possible, like a fun competition. Then, one would like afterwards, to see them thinking and commenting and build again, but that time does not exist. But it would be optimal." (Dagny)

Assessment

All respondents assess much of their pupils' work formative, as they walk around in the classroom and look at how the pupils act. They all say that when they have one-to-one discussions with a pupil or pupil group they hear and see if the pupil understands the contents. Most of them use reports and presentations as summative processes. Two of the respondents use written tests in order to check the pupils' knowledge.

Discussion and conclusions

Teaching technology

Looking at the respondents' teaching, one notices differences between the teachers in how they plan their teaching, but also similarities in how they conduct their teaching. There are differences in how time is allocated between the theoretical and practical elements and in strategies the teachers use the subject content. But most obvious is the similarity of the subject – the tradition in school is activities centered on designing and making. All respondents use practical activities when conducting technology lessons. The respondents' teaching is based largely on building and designing. The teachers all mentions that one major reason for spending so much time on designing and making, even though it is not demanded by the curriculum, is that the pupils like it. Many of the practical elements are implemented by the teachers because they want pupils to think that technology is fun.

The respondents have different ways of teaching. Dagny and Bertil take part in competitions and mention that both learning objectives and core content are included in the competitions. Adam seldom works with groups of pupils, while Cesar and Dagny say they always have the pupils work in groups. Three of the teachers also teach science. As Norström[32] and Skogh[33] mention, a subject with no consensus regarding the content and practice will result in insecure teaching and varying levels of knowledge among pupils.

Compared with other subjects, very little time is dedicated to technology. The Swedish Schools Inspectorate (*Skolinspektionen*) reasons in its 2014 report[34] that the subject should be assigned about 200 hours thru grades 1– 9. The teachers in this study have between 90 – 105 hours to implement the core content for year 7– 9, which is considered sufficient. This good

situation might be due to all the schools being part of the Tekniklyftet project, which aimed for sufficient time for technology education.

The teachers all mentioned that they don't have enough time for the curriculums complete core content. It is perceived by teachers as being too extensive and broad, despite having sufficient time scheduled for the subject. The respondents describe that they plan their teaching in order to connect with the learning objectives, core content and how they work with parts of the core content. The National Agency for Education states in a booklet of general advice for teachers, – *Planning and Implementation of Teaching*,[35] that "It is not allowed to omit or move parts of the core content to other grades than stated in the syllabus." Nevertheless, this is frequently done by the respondents in this study. The teachers do not determine whether an alternative planning and conducting of lessons can help them to include the complete core contents. On the other hand one might ask if the curriculum is too broad and extensive to be completed within the required timeframe.

Teachers' backgrounds
One difference among the respondents is their backgrounds. Bjurulf [15] means that teachers' education is important for structure and content. Three of the teachers teach science and math in addition to technology. Bertil, with a background as a crafts teacher, has the most practical approach to teaching technology among the respondents. Adam, with a background as an engineer, talks about teaching the pupils the engineering approach of problem solving. Both Bertil and Adam use earlier education and experience in their teaching to give structure to the lessons. Bertil uses most of scheduled time for practical activities, in ninth grade that is almost all scheduled time. Adam uses less than 50 % of the lessons in practical activities. In science class teachers usually use an investigative approach where theory is tested in a laboratory experiment during one lesson. However, teaching technology is not planned in a similar way. Instead, areas with practical sessions often take several weeks to completion. One could ask why technology lessons taught by a teacher with a background in science so seldom use experiments and laboratory exercises in class instead of practical activities that take a long time.

Subject educated teachers
Reports from both the Schools Inspectorate[36] and Technology Delegation (*Teknikdelegationen*)[37] expresses concerns about future education in engineering due to the absence of skilled and trained subject teachers. Research shows that the role of the teacher in the classroom is critical to student learning, which Hartell et al.[17] also point out. Technology education needs to be conducted by trained technology teachers with knowledge of the curriculum and knowledge in the subject.

The way teachers design activities is based on both knowledge of the subject (subject matter) and knowledge in pedagogy, and as all teachers have different background the design will result in different pedagogical content knowledge. A subject with no consensus regarding content and practice, as Norström[8] and Skogh[33] mention, it will result in insecure teaching. One can therefore argue that a further developed concept of content knowledge and,

specifically pedagogical content knowledge, in line with Shulmans' theories,[23] [24] can help develop the education of new technology teachers as well as complementing established teachers' knowledge and work in the subject.

Conclusion

This paper discusses similarities and dissimilarities in teaching strategies, and views that teachers, with different backgrounds, express concerning the subject of technology. Although findings in this study must be viewed in the light of the limited number of respondents some important aspects has been highlighted. All teachers in this study say that they enjoy teaching technology. This is positive for a school subject that for a long time has lived in the shadows of the natural sciences subjects.

According to collected data the respondents use a number of different methods in their teaching. Here teachers' backgrounds are found to be a significant influencing factor in how the subject is taught.

A common denominator amongst the studied teachers is the perceived lack of time for teaching technology. Not least the core content stated in the curricular is perceived as too extensive and therefore hard to cover.

The question of how to make the best use of time available is also raised. Findings of this study indicate that practical activities outweigh theory. It seems like theory, by these teachers, is seen as an implied effect of practical activities.

To promote student learning and skill development, teaching should, in accordance with the curriculum, be planned based on the students' background, previous experiences, language and knowledge, and the overall curriculum objectives and syllabus of the subject.[38] The curriculum does not specify how much time that should be devoted to various aspects of the core content which give the teacher freedom to adapt their teaching to the student body and available resources. This, however, is also a big responsibility. To be able to take on this responsibility, teachers must be well trained, and policy documents must be elaborated and realistic.

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Appendix 1: Questions

1. a) What do you include in the concept of "practical work"? (in general? in technology education?)

   b) What do you include in the concept of "practical approach"? (in engineering education? in another subject [mathematics, Swedish, ...]?)

2. a) What in your teaching do you consider "practical"?

   b) What in your teaching do you consider "theoretical"?

3. Which areas of technology education do you deem particularly suitable for a practical or theoretical approach?

4. a) What do you think is the advantage of practical sessions? What disadvantages do you see? (in general and in technical education)?

   b) What do you think is the advantage of theoretical sessions? What disadvantages do you see? (in general and in technical education)?

5. In what amount of your technology teaching do you work with practical sessions?

6. a) What goals do you have when you work with practical sessions?

   b) How do you make the goals clear to students?

7. How do you set up group work in engineering education? (objectives, instructions, logistics, materials)

8. How do you evaluate / follow up your own goals and goal achievement?

9. How do you assess the student or group effort? (What methods and criteria do you select when you assess?)

10. How do you assess a student groups work process based on technology developments different phases?

Specific for technology education: time, equipment, money, local traditions, and teacher's background.