Design and Technology Education: An International Journal

29.2

Timeless, socially relevant engineering knowledge and skills for future education

Per Norström, KTH Institute of Technology, Sweden
Susanne Engström, KTH Institute of Technology, Sweden
Birgit Fahrman, KTH Institute of Technology, Sweden

Abstract

What pupils learn in school should ideally be useful throughout their whole lives. It should help them in further studies, in working life, and when acting as responsible citizens in democratic society. This is challenging for all subjects, including technology. Technology develops fast. It is most likely that wheels, wedges, and inclined planes will be used in the future, but it is difficult to know which programming languages, sources of energy, and materials that will be relevant a few decades from now. This article describe how these problems are handled in international curricula and standards, and by Swedish teachers, teacher students, and teacher educators. In curricula they are seldom addressed explicitly, but handled by giving deliberately vague descriptions of what students are to learn. The interviewed teachers, teacher educators, and teacher students were unused to think about future-compliant or timeless knowledge. When prompted to do so during the interviews, they found it easier to describe timeless skills than timeless factual knowledge. Prominent among their suggestions were abilities related to engineering design processes, technical problem solving strategies, fundamentals of computer programming, and engineering mechanics.

Keywords

engineering education, future compliant knowledge, secondary school, technology education, timeless knowledge

Introduction

What students learn in school should ideally be useful both right now and well into the future: it should be timeless or future-compliant. Students learn to enable them to study, help them in their everyday lives, prepare for professional careers, for being able to participate in a democratic society, and more. It is not obvious how an educational system should be designed to increase the likelihood of the studied subject content being valid when the students grow up. The passage of time in itself leads to an inherent transfer problem: Schools mainly teach students about today's society to enable them to function in a society ten, twenty or thirty years in the future. Trying to teach students about the future is difficult, as predictions of the future concerning most aspects of society are notoriously unreliable (e.g., Inayatullah, 1990; World Economic Forum, 2023).

Since the 1990s, content related to technology and engineering has been introduced in curricula all over the world. In some countries (e.g., Sweden, New Zealand, England) it has been in the form of separate subjects while other have integrated it in other subjects, often crafts or natural science (e.g., Finland, the Netherlands, parts of the United States). Predicting future usefulness of technological knowledge is difficult. ITEA's *Standards for technological literacy* (2007, p. 1) describe the situation thus:

> *Because technology is so fluid, teachers of technology tend to spend less time on specific details and more on concepts and principles. The goal is to produce students with a more conceptual understanding of technology and its place in society, who can thus grasp and evaluate new bits of technology that they might never have seen before.*

Technology's 'fluidity' (ITEA's expression) does lead to special challenges. To even identify the 'conceptual understanding' that will withstand the test of time is difficult. Think of how the debates about nuclear power and wind power, the role of mobile telephones, and the use of artificial intelligence have changed during the last decades. Some changes have occurred quicker than expected (e.g., smartphones) while other have been surprisingly slow (we still wait for cold fusion and the autonomous vehicle revolution). In Sweden, what pupils learn about technology in school at the age of 13 should ideally be immediately useful, but also aid them in choosing a suitable branch of secondary education at the age of 16, and to understand political, ethical, and practical technological problems throughout their adult lives (SFS 1010:800, Skolverket, 2024, pp. 12–13, 17). How curriculum designers, standards authors, and educators should address this is not obvious. Future usefulness of technological knowledge has not been a major theme in educational research. In an overview of articles published in the leading journal *International Journal of Technology and Design Education* between 2005 and 2014, future-related terms are absent from the lists of common keywords and seldom occur in article titles (Christensen et al., 2015).

Aim and research questions

The purpose of this study is to find how key players in introductory technology and engineering education (e.g. curriculum designers, standards authors, teacher educators, and teachers) try to increase the likelihood for pre-university (K–12) technology and engineering education to be relevant for the learners later in life. The following research questions have guided the study:

1. What characterises timeless and society-relevant technological knowledge according to key-players in introductory technology and engineering education?
2. How do teachers, teacher educators, and teacher students describe their attempts to include timeless, society-relevant knowledge in introductory technology and engineering education?

Background: Technology education in Swedish schools

The interviews in this study concern the situation in Sweden. The interviewees are Swedish teachers, teacher students, and teacher educators. Many of the problems and opportunities they discuss can also be experienced in other countries, but when they refer explicitly to curricula, syllabi, etc., they talk about Swedish documents and practices.

Swedish youngsters attend compulsory school between seven and sixteen years of age. Technology is a mandatory subject for all pupils, with a total of 200 hours of contact teaching spread out over the nine years. All subjects are described in a similar way in the national curriculum: an introductory text stating the subject's purpose and overarching content, followed by a short list of general skills (three in technology) to be practiced. Core content for years 1–3, 4–6, and 7–9, presented in bullet point lists accompany the skills. The final section contains grading instructions (Skolverket, 2024a, pp. 267–273). The curriculum is open to interpretation, and teachers have opportunities to adapt it to fit their own interests and areas of expertise, as well as their schools'' resources.

Concerning content, the Swedish technology subject in compulsory school is broad, and includes common school-technology content like the design process, materials, introductory computer programming, and technical drawing. Compared with many other countries' subjects, it includes large parts about the history, sociology, and politics of the technological domain.

The nine years of compulsory school are for most students followed by three years of upper secondary school. One of the programmes in upper secondary school is the Technology programme, which prepares students for work or higher education within the science and technology domain. Approximately 8% of Swedish students choose the Technology programme, with considerable regional differences (Skolverket, 2024b). While technology education in compulsory school is for all pupils, upper secondary school is only for those that have chosen it. This leads to the education having a slightly different profile, with more 'hard' engineering content and applied natural science, and less of the historical and sociological perspectives (Skolverket, n.d.).

Method

Data concerning curriculum designers' and standards authors' opinions, suggestions, and visions were collected indirectly through the study of relevant documents. Data concerning teachers', teacher educators', and teacher students' thoughts on timeless technology knowledge and how it should be included in technology education were collected through group interviews.

Theoretical outlook

Douglas Roberts (2007) described two major visions of science education, which are useful for describing technology education as well. *Vision 1* is looking inwards, the need for scientific knowledge is justified by referencing science itself. Science and scientific activities are mainly studied as separated from society and the world at large. This is in contrast to *Vision 2*, where the starting point for education are situations and problems in society. The need for scientific knowledge is justified referencing societal and individual needs. Science is according to *Vision 2* regarded as part of a larger body of knowledge that includes politics, culture, and the ins and outs of everyday life. Whether a *Vision 1* or a *Vision 2* outlook dominates a curriculum, a textbook, or an individual teacher's preferences affects what kind of timeless knowledge that is emphasised. According to *Vision 1*, technical skills, working methods and principle are put forward whereas those adhering to *Vision 2* instead focus understanding of how technology affects and is affected by society, now and in the future. Related to his *Visions*-system is Roberts' (1982) description of *curriculum emphases*. The emphases describe seven types of purposes that are common in science curricula. They provide answers to the question '*Why should pupils learn this?*' Adapted to a technology education context, the answers (purposes, emphases) are: (1) to manage in everyday life (*everyday coping*); (2) to understand how technology functions intellectually (*structure of technology*); (3) to be able to use technological knowledge, e.g. in political decisions (*science, technology, and decisions*); (4) to master processes used in technical tasks (*technological skill development*); (5) to learn what is true (*correct explanation*); (6) for the joy and engagement in explaining technical phenomena (*self* *as explainer*); and (7) to provide a knowledge base for future studies and work (*solid foundation*).

Curriculum, syllabus, and standards analyses

The studied documents include curricula, syllabi, and standards. They represent a convenience sample. All are easily available online and published in any of the limited set of languages that the article’s authors read (Danish, English, Norwegian, and Swedish). A rough digital search through the documents, looking for terms like ‘ future’ and ‘timeless’ was performed. The documents were then read repeatedly, looking for comments about timelessness and/or future usefulness, and content that was relevant for a discussion of timelessness.

Group interviews

The respondents consisted of five groups, gathered through convenience sampling:

- Lower secondary school technology teachers. Three experienced teachers, all former engineers. They work in a municipality-owned school, located in an upper middle-class area near the city centre
- Lower secondary school technology teachers. Four experienced teachers, with varying backgrounds. They work in a municipality-owned school, located on the outskirts of the city
- Upper secondary school technology teachers. Three experienced teachers, all former engineers. They work in a municipality-owned school that is specialised in computer science and invention
- Technology teacher students. Nine former engineers, participating in a bridging teacher education programme at a Swedish university with the aim of becoming secondary school teachers
- Technology teacher educators. Five teacher educators (lecturers, senior lecturers) representing four different higher education institutions in Sweden

Group interviews enable respondents to discuss and develop their answers together. Through the jointly conducted dialogue, they may develop responses further. The interviewers can ask questions to encourage clarification and nudge the respondents if the conversation comes to a halt. Having a safe environment for the interview is important (Marshall & Rosman, 2011). The respondents within each group were well acquainted with each other – they were colleagues at a school, students in the same education programme, or teacher educators who meet regularly. The interviews were carried out at the teachers’ workplaces, the students’ university, and at a national meeting for technology teacher educators.

The keywords ‘Timeless, socially relevant engineering knowledge and skills for future technology education’ were written in Swedish on a whiteboard (Sw. ‘*Tidlösa, samhällsrelevanta, ingenjörsvetenskapliga kunskaper och färdigheter för framtida teknikundervisning*’). These words served as a starting point for the discussion, and both interviewers and interviewees returned to them during the conversation. Each group interview took between 30 and 60 minutes. The interviews were conducted in Swedish. They were recorded (audio only), transcribed verbatim, and translated into English. Data collection was conducted over an eighteen-month period. The first interview took place during the autumn of 2022 and the last one in the spring of 2024.

Analysis of interviews

Analysis of the interviews started with an inductive thematic analysis of the transcripts, based on Braun's and Clarke's (2006) six step method. Patterns and themes were identified and refined through repeated reading. All authors participated in the thematic analysis.

Results and analysis

Curriculum designers' and standards authors' views of timeless knowledge

The content and purposes of technology subjects vary between countries. For example, only some include computer programming. Although most curricula incorporate some kind of design or product development process, there are important differences between them. In some countries (e.g., Finland and Scotland), technology subjects are largely craft based, while others (e.g., New Zealand and Sweden) have a broader approach. This affects how easy and how relevant it is to consider timelessness during curriculum design.

The documents' scopes, styles, and levels of detail varies considerably. Some only contain a framework that allows teachers to fill in the details. Others are detailed and even provide examples of how to teach. Key Stage 3 in the English syllabus for Design and technology (Department for Education, 2013) is an example of the former, while the corresponding Australian document (ACARA, 2015) accords with the latter. The English syllabus consists of three pages in total: an introductory paragraph followed by a list of themes presented as bullet points. By contrast, the Australian document contains approximately 50 pages (including example tasks and a glossary). Another difference concerns which and how much information that is included in subject specific syllabi, and how much that is placed in some general curriculum document that concerns all subjects. The technology subjects also have different overall approaches concerning what the students are to learn. In Roberts' (2007) terms, *Vision 1* dominates the technology curricula of e.g. Scotland (strong crafts focus; Scottish Qualifications Authority, 2012) and Massachusetts (where information and communications technologies are emphasised; Massachusetts Department of Elementary and Secondary Education, 2016). Curricula from Sweden, Denmark, and New Zealand with their social science and history content show clear signs of *Vision 2*. This makes direct comparison between the syllabi awkward, and not very useful. Instead, we will provide an overview of different ways of considering (or omitting) timeless knowledge in curricula and standards for pre-university technology and engineering education.

The overall structure of most technology curricula are similar. They start with a few introductory paragraphs, followed by a list of content areas, and in many cases guidelines for grading. There are a few exceptions, such as the aforementioned voluminous documents from Australia and Massachusetts. These are more like reports about the respective subject, with comments, teaching suggestions, and descriptions of how technology, engineering, and/or STEM studies fit into the greater whole (ACARA, 2015; Massachusetts Department of Elementary and Secondary Education, 2016).

Timelessness and the future in introductory sections of curricula and syllabi

The syllabi's introductions typically contain a short description of why pupils should learn about technology, which often includes comments about future studies, working life (*solid foundation*; Roberts, 1982), and being an active citizen in a democratic society (*science, technology, and decisions*; Roberts, 1982).

The Danish syllabus for technology and natural science (Børne- og undervisningsministeriet, 2019) states that learning in science and technology should be based on pupils' personal experiences and contribute to their overall understanding of the world. They are to develop a STEM related vocabulary, as well as technical skills and ways of thinking that can be useful in everyday life (*everyday coping* and *self as explainer*; Roberts, 1982). Finnish pupils are to develop broad knowledge and understanding of the world: Knowledge in technology and sloyd are important building blocks in this endeavour (*technological skill development*; derived from Roberts, 1982). The syllabus' introduction reminds the reader that humanity is responsible for developing technology in a way to improve the future of nature and society. Pupils should develop knowledge that is useful when working to correct non-sustainable lifestyles. Their responsibilities stretch over multiple generations (Utbildningsstyrelsen, 2014). In the United States, the National Research Council (2013, p. 112) also encourages educators to make sure that pupils learn the bigger picture to prepare them for a responsible life in a complex world where questions concerning science, technology, society, and the environment intermingle (*science, technology, and decisions*; Roberts, 1982).

Technology education for senior students in New Zealand show its *solid foundation* intentions when it 'opens up pathways that can lead to technology-related careers' (Ministry of Education, 2018, p. 1). Even Welsh pupils are to be prepared for working life by learning useful skills, and also be taught about possible careers in technology and engineering (Department for Children, Education, Lifelong Learning and Skills, 2009).

Timelessness and the future in subject contents

As is obvious from the abovementioned examples, curriculum designers commonly consider the necessity to prepare pupils for the future, to provide them with future-compliant skills and knowledge – knowledge that can be useful both now and when they grow up. These suggestions and discussions are however most visible in the syllabi's introductory paragraphs. They are part of the subject's overarching goals, but very little is said about how to make this concrete and tangible in the classroom. Teachers and textbook authors have to take responsibility for the implementation.

The main strategy for describing timeless knowledge is by using very general terms and expressions. For example, the Irish syllabus for design and technology includes a section about materials technology. It states that students should learn about properties of materials, materials processing, surface treatments, quality assurance, etc. (National Council for Curriculum and Assessment, 2006, pp. 35–36). The section does not mention any single material, but only families: metals, wood, composites, polymers, fabrics, and ceramics. An advantage of this is that the syllabus is reasonably future-safe. Most materials that were in widespread use when the syllabus was written fit into these categories, as do most materials invented since then. A drawback is that teachers get very little guidance concerning prioritization and which materials to include. All materials are probably not as important. Both ivorite (an early 20th century plastic) and polyethylene (which is in widespread use today) belong to the family of plastics. Nevertheless, it could be argued that they are not as important to learn about (at least not important in the same way). Another drawback is that not all potentially interesting materials fit into the listed categories, however inclusive. A teacher who wishes to include newly discovered allotropes as graphene and fullerene gets no support from the curriculum, even though many materials scientists believe that they will become important in a near future (Geim & Novoselov, 2007).

Similar strategies are used to describe skills that students are to master. The descriptions are abstract, and thereby likely to be timeless. The Swedish syllabus for technology states that students are to learn about the different phases of the product development process: identification of needs, proposal of solutions, design and testing, etc. (Skolverket, 2024a). This can be applied to almost any described design process, from the 'water fall' or 'over the wall engineering' models of the 1970s to the agile methods of today (Abbas et al., 2008). The syllabus' description of the subject content is timeless by containing very little information. Teachers get next to no guidance for their decisions. Whether they should teach established methods that are easy to grasp, or modern ones that supposedly are more efficient is not stated by the syllabus.

The Swedish curricula and syllabi

The introduction to the Swedish curriculum describes the purpose of schooling, and states that pupils should learn to make informed decisions concerning their own futures. A historical perspective should permeate all school activities, preparing pupils for the future and 'develop their ability to think dynamically' (Skolverket, 2024a, pp. 15, 36,6 quote from p. 8). The Swedish technology subject (Skolverket, 2024a, pp. 267–273) has no explicit future perspective. The term 'future' (Sw. '*framtid*') is nowhere to be found in the syllabus, but perspectives of timelessness and the future are implicit in expressions dealing with sustainable development or development in general.

In upper secondary school, timelessness and future perspectives are not mentioned explicitly in the syllabus, but can be seen as included implicitly in statements about sustainable development, entrepreneurship and preparation for working life (Skolverket, n.d.). To what extent and in what forms ideas about timeless and future-relevant technological knowledge manifest in technology education in compulsory and upper secondary school in Sweden is mainly up to the teachers. The curricula and syllabi provide very little guidance and support.

Teachers', teacher educators', and teacher students' views of timeless knowledge

When comparing statements from the different groups of respondents, both similarities and differences came up. These concern what kinds of themes that were discussed, and how they were addressed. The lower secondary school teachers highlighted examples from their own teaching practices. They repeatedly returned to what pupils would find interesting or difficult. They also made more frequent references to the curriculum documents than the other groups. The upper secondary school teachers stressed the need to be skilled in maths for a future career in technology, which the lower secondary school teachers did not. The teacher educators focused on the challenges of teachers and teacher students. They talked about how teachers should stand up and be proud of their subjects, and the need for courage and self-confidence for the ability to teach. The participating teacher students, of whom many had recently worked in engineering, referred to their own experiences as pupils and students. Just like the upper secondary school teachers, they mentioned maths as essential for careers in technology or engineering, but also self-confidence, initiative, and curiosity.

For all respondents, it seemed challenging to discuss the abstract concept of timeless knowledge, or even knowledge that would stay useful over time. In many cases, the discussion drifted towards engineering skills and abilities (“knowing how”). Propositional knowledge (facts, “knowledge that”) stayed in the background for most of the time. Even though the questions posed and the starting point slogan concerned knowledge, the discussion in many cases drifted towards attitudes, feelings, and values.

Digital tools, systems understanding, problem solving, engineering design, and a curious but critical attitude were among the central aspects of timeless, socially relevant, engineering knowledge that the teachers, teacher educators, and teacher students discussed. Below, these are organised as themes that emerged from the entire material, across all participant groups.

Timeless facts as content in technology education

The respondents highlighted certain facts and content in different technological areas that they believed would remain relevant, and referred to these as ‘timeless’, ‘necessary for all engineers’, and ‘indispensable parts of technological literacy’. They were considered important mainly for their usefulness in future studies and in everyday life (*solid foundation*, *everyday coping*; Roberts, 1982). The most commonly mentioned areas were computers, programming, electronics, energy, and mechanics. The lower secondary school teachers highlighted technical systems and the built environment. The upper secondary school teachers also mentioned the history of technology.

Fundamental programming concepts such as variables, conditional statements, and loops were considered central concepts that will withstand the test of time. The secondary school teachers also mentioned common electronic components, their names, and use. The upper secondary school teachers stressed the need to understand how to combine electronic components with computers and processors to perform automatic control tasks.

> *If you want to be more hands-on, so that skills and knowledge … Then we say in technology that those students learn CAD, programming, and electronics as a common thread; so they can manufacture all sorts of things.*
> (*Upper secondary school teacher*)

Teachers, teacher educators and technology teacher students all mentioned classical mechanical technological solutions such as levers, inclined planes, and screws. One of the teachers reminded the rest of the group that they are truly timeless: ‘they have been at the core of technology education since antiquity and will be used forever.’ In another group interview, these fundamental mechanical principles are compared to standard features in programming languages:

> *You want to get in early with what you were talking about basic components – wedge, screw, inclined plane, those things – to get an understanding that you use it. It is a bit like physics. This is however applied physics, which fits the technology subject. But programming and such, it also has basic building blocks: that you can do a loop, that you have a choice of different options. That is just like the wedge, and the screw, and the inclined plane. They are basic building blocks that can be combined, just as programming has its basic building blocks.*
> (*Technology teacher student*)

Energy, especially the production of electricity, which is an important political question, was also mentioned numerous times (traces of *science, technology, and decisions*; Roberts, 1982). The discussion never really took off, however. The reason for this could be that energy, energy distribution, and energy politics, traditionally belong to the subjects of physics and civics in Swedish curricula.

Timeless methods and ways of reasoning

It was obvious that the respondents found it easier to discuss timeless methods, procedures and ways of working and reasoning, than propositional content knowledge. The selection was mainly motivated by its usefulness in future studies and work, and for the joy of knowing (*solid foundation*, *self as explainer*; Roberts, 1982). Several times, strong beliefs in the possibility of transferring a method or a way of working from one domain to another were expressed. This concerned areas such as the writing of technical reports and being able to carry out a general engineering design process, applicable for many kinds of technical problem solving or product development tasks.

> *To be able to work with the design process based on models and in that way be able to solve problems and that it can be some kind of core of knowledge.*
> (*Technology teacher educator*)

Teaching a structured design process has been the core of technology education in many countries for a long time (probably most notable in England). The Swedish technology curricula have always described a broader subject, in which design and product development is just one theme among others (Skolverket, 2024a, n.d.). Nevertheless, even in Sweden the learning of a design process is considered essential and timeless technology education content. The upper secondary school teachers mentioned how product development and engineering design work encourage curiosity and provide a framework for learning about general technological phenomena. The lower secondary school teachers also mentioned this, for example in relation to learning about how to write technical reports and how to use flowcharts and technical drawings. The teacher students talked about the importance of learning how to reason and collaborate, and how design and development work could provide an environment for this.

> *It starts with – among other things – what product development actually is, and some examples of products. Where do the products come from? What are the driving forces behind why these products have been invented? Why do they exist? And discuss it … The products we have chosen are Swedish or where Swedes have been involved, such as mobile phones, milk cartons and refrigerators. We start the discussions from there. How is it that? What was it like before there was a need? How has it evolved over time?*
> (*Lower secondary teacher*)

The upper secondary school teachers, of whom many were keen on programming, mentioned software engineering as an important form of design or product development work. They described the procedures for systematic testing, analysis, and debugging of software as to some degree transferrable to other technical domains:

> *The students have practiced this a lot. To identify target groups, do test cases, improve their products, and think in an innovation-way; all this stuff that they just try to express.*

> *The knowledge they have then gained through CAD, electronics, and programming, and other things … They can use it to build a work of art with technology, and express something that is important. There I think that we have trained both of these aspects: both going into oneself and going out to get feedback from others. And it works, the students can transfer this knowledge from the technical context and later use it for something else.*
> (*Upper secondary school teacher*)

Preparation for future studies, everyday life, and work
Many respondents stress the necessity for students to develop a positive attitude towards technology, both for further studies and for managing their daily lives. The respondents expressed how technical self-confidence, interest in technology, and higher studies in technology are timeless, and in need of constant further development. Certain skills and abilities are highlighted. Despite our questions focusing on knowledge and skills, the need to develop sound attitudes towards technology and engineering was brought up numerous times. The respondents described how a timeless, socially relevant, engineering-focused attitude must be positive towards and comfortable with technology. The subject have to be permeated by a desire to investigate, discover, and solve problems, combined with a will to understand one's choices and opportunities to work hands-on with different technologies. The respondents emphasised the importance of practical applications and that the educational system constantly needs to evolve to prepare students for lifelong learning and adaptation to new technological advances. Especially the upper secondary school teachers highlighted that an innovative attitude can open doors and improve opportunities.

The respondents underscored the importance of a basic understanding of technology, the ability to solve problems, and the significance of being able to navigate in an increasingly digitalized world. A part of this is the need for rudimentary knowledge of computers and computer programming, by some respondents referred to as 'computational thinking' or 'general digital competence'. To varying degrees, all respondent groups described this as necessary for future studies, work, and everyday life (*solid foundation, everyday coping*; Roberts, 1982).

> *Since everything is becoming increasingly digital today, one could argue that programming is part of fundamental technological knowledge. You should easily understand how all these systems work on a rudimentary level, how the code looks, and how it is accepted, then what it is and what capacity it has. There is a lot of talk about AI and machine learning today, but at its core, it is based on statistics.*
> (*Technology teacher student*)

This underscores the importance of basic programming knowledge and understanding of statistics (which is part of the Swedish mathematics subject) and digital systems as timeless and necessary competencies.

The respondents also emphasise the significance of students' developing an understanding of large technical systems, and the systems' interactions with society. This knowledge can enrich students' academic journey and equip them with skills to effectively and efficiently navigate and influence complex systems in their daily lives and future professions, and better understand the relations between technology and society at large.

Furthermore, the upper secondary school teachers pointed out that engineering design work encourages information retrieval skills and critical thinking. If the project is large enough, and authentic enough, pupils will repeatedly run into problems that neither they nor their teachers know how to solve. Efficient use of a search engine is therefore considered a timeless skill for engineers and technicians. The upper secondary school teachers remarked that internet searches often can be quicker than trying to find the answer in a textbook or handbook:

> *Google it, and see what you can find. There is a lot of rubbish out there, but also useful stuff. You learn how to find it by trying.*
> (*Upper secondary school teacher*)

Environmental awareness, life cycle analysis, risk assessment, and mathematical and physical modelling are also considered timeless skills that can be practiced in a design process environment. An attitude towards technology that will withstand the test of time is also described as action-oriented, curious, and insightful about how the world works. Throughout the educational system, students should be encouraged to develop a personal desire to learn and a willingness to face technical problems that they cannot yet understand.

Application of societal, political, ethical, and existential questions

Environmental impact or ethical implications of technologies were mainly discussed in terms of attitudes. The respondents discussed the need for pupils to develop an environmental awareness, and recognize their own (and the Western world's) roles in the technosphere. They did however not discuss how this could be achieved, or how these attitudes could encourage scientific evaluation of the impact of lifestyle choices or novel innovations. The suggestions never went beyond developing a general awareness of possible problems, and the need for a positive attitude towards the possibilities of finding solutions. The respondents talked about how an innovative, self-directed, and playful attitude is important for students' will and abilities to approach timeless, socially relevant, and engineering aspects with their mental 'problem-solving toolkits.'

The respondents also highlight the importance of understanding how political decisions and economics affect technical development. An example that came up concerned factors that influence electricity prices in Sweden. To develop an overview of this and being able to discuss the combined impact of technology, policy, and international trade, is considered to be both important and timeless, especially by the secondary school teachers. Related to this is the respondents' focus on social responsibility, ethics, risk assessment and inherent values in technology and engineering (traces of *science, technology, and decisions*; Roberts, 1982). This includes insights into how technology affects the environment and emphasises the importance of sustainable development:

> *I think a lot about the social responsibility that comes with the knowledge about technology. It can be managed and refined with some sort of sense of values and ethics. Especially if you think about technology education in compulsory school, where it is mandatory, it is important that it benefits society as a whole. More so than in upper*

> *secondary school.*
> (*Technology teacher student*)

These statements highlight how social responsibility and environmental awareness may be integrated in technology education, and underscore the need for a precautionary principle when applying technical knowledge. The respondents talk about how deep understanding of systems thinking is crucial for effectively managing technical and societal challenges.

Discussion

That students are supposed to learn for the future is challenging for curriculum designers, textbook authors, teachers, and the students themselves. This is true for all subjects, but introductory technology and engineering have many special difficulties. One is of course that technology is prone to change. Humanity will almost certainly use wheels, resistors, and concrete thirty years from now. Whether the programming language Python, small modular nuclear reactors (SMRs), and combustion engines will be in widespread use is not as certain. It is difficult to predict what should be prioritised in technology education for best outcome.

Handling timeless knowledge … or not

Curriculum and syllabus designers have addressed the challenge of identifying timeless knowledge mainly in two different ways. They have either ignored it or tried to handle it by describing the content of their subjects so vaguely that they become timeless through their lack of real substance. The Swedish technology subject is an example of the latter. One of the overarching learning areas is ‘knowledge of technological solutions and how constituent components work together to achieve suitability and function’ (Skolverket, 2024a, p. 268). It is a goal that seems reasonable in a Stone Age context (sticks, strings, and a sharp stone make an axe), today (metal tubing, wheels, pedals, chain, and sprockets make a bicycle), and in the future. Through its vagueness, the curriculum manages to be future-safe. It does however say very little about students' intended knowledge. If they learn about the components of a bicycle, will they be able to use this knowledge in other contexts? If bicycles are no longer used, or just their chains replaced, the value of today’s knowledge of bicycles and their components is reduced. If the students have achieved some abstract, general component–whole knowledge (a form of systems thinking) it could be applicable in a variety of contexts and therefore useful. Otherwise, their knowledge will be of historical value only. It is obvious from curriculum studies that the main responsibility to create a technology subject that encourages learning that will withstand the test of time rests on the teachers.

Teachers, teacher students, and teacher educators expressed ideas about on the one hand timeless skills, abilities and attitudes, and on the other hand propositional knowledge. Most responses concerning future usability of technological knowledge concerns future studies (*solid foundation*; Roberts, 1982). Among the skills, they mentioned the ability to follow a structured engineering design or product development process, and to write a simple computer program. Curiosity was mentioned as an important attitude, especially if combined with an ability to critically evaluate various technologies (positively or negatively). Suggestions for which propositional knowledge that will be useful in the future were not as numerous but included the five simple machines from antiquity and fundamental constructs from computer programming.

The purpose of technology education

It is obvious from the teachers' answers that they do not really agree about the overarching purpose or vision of the technology subject. The former engineers now working in technology education were obviously influenced by their earlier careers when thinking about technology and technology education (compare Fahrman et al., 2019). They emphasised the necessity to learn about design processes, electronics components, and computer programming without making explicit references to non-technical phenomena. Their students learn about technology for technology's sake (*Vision 1*; Roberts, 2007), to prepare for future studies and work in the technological domain (*solid foundation*; Roberts, 1982). Among the other lower secondary school teachers, social responsibility and ethics are put forward. As stated above, they discuss the energy system and its environmental and economic effects. This is a problem complex typical of Roberts' (2007) *Vision 2*, complex and value-laden.

Timeless abilities and skills

The skills and abilities that are put forward by the respondents belong mainly to the domains of traditional subject content in introductory technology and engineering education: project work, technical drawing and sketching.

The upper secondary school teachers also highlight the necessity to be able to use internet information sources efficiently. To what extent learning to use the search tools of today will be of help in the future is of course hard to predict. Since the introduction of large-scale search engines in the late 1990s, the trend has been towards ease of use. The need for information literacy and ability to evaluate sources of information will most likely still be indispensable, but to what extent there will be a need for search training is very difficult to estimate.

Timeless attitudes and ideals

The respondents repeatedly talk about on the one hand curiosity and an open mind, and on the other hand a critical, questioning attitude when it comes to technology. Interestingly enough, none of them described or even provided examples of activities and content that encourage this.

Timeless propositional knowledge

Factual knowledge is the area in which the respondents have the greatest difficulties concerning finding proper answers to our questions.

Many themes described are closely related to the skills and abilities: students are to learn the names and functions of electrical components to be able to use them in systems for automatic control, for example. The propositional knowledge thereby becomes closely connected to the abilities and skills, which is typical of the technological domain (Norström, 2015).

Somewhat surprising, there were very few comments concerning how technological artefacts and systems work and/or are part of the infrastructure. It could be argued that knowledge about for example nuclear power and its radioactive residue will be useful in the foreseeable future. In spite of this, none of the respondent groups mentioned it.

Conclusion and future studies

The necessity of timeless knowledge is inherent in the very idea of schooling. The purpose of students’ learning lies in many cases far into the future. Their knowledge should be useful in future studies, working life, and for being able to be an active member of democratic society. Judging from our curriculum studies and interviews, this has not been adequately addressed in technology education. Teachers get very little support and have few guidelines that could help them to take the perspective of timeless or future-compliant knowledge seriously.

The interviewees were teachers, teacher educators, and teacher students. They were however few and not randomly selected. They had different backgrounds and worked in schools of different kinds. Exactly to what degree their ideas and experiences are typical is therefore impossible to know, but it is likely that similar understandings (or lack thereof) are common in schools elsewhere. The interviewees were clearly unused to discuss students intended learning from a future-oriented perspective. Their mentioned examples were mainly skills related to design and programming. characterised by their usefulness mainly in future studies and in everyday life. Political implications of technology and engineering were mentioned briefly in connection with electrical energy. Nobody mentioned any strategies or methods for making sure that the subject content is still valid and relevant.

This study has an exploratory approach. It would be very interesting to conduct follow-up studies with teachers and teacher educators in other countries. It would also be interesting to conduct a thorough study of textbooks, teachers' handbooks and other artefacts intended to support teaching and learning. Preliminary studies of Swedish textbooks indicate that they do not compensate for the shortcomings of the curricula.

References

Abbas, N., Gravell, A.M., & Wills, G.B. (2008). *Historical Roots of Agile Methods: Where Did 'Agile Thinking' come from?* Conference paper from the 2008 International Conference on Agile Processes and Extreme Programming. DOI: http://dx.doi.org/10.1007/978-3-540-68255-4_10

[ACARA] Australian Curriculum Assessment and Reporting Authority. (2015). *Design and Technology: Sequence of Content F–10*. https://docs.acara.edu.au/resources/Design_and_Technologies_-_Sequence_of_content.pdf

Børne- og undervisningsministeriet [Danish Ministry of Children and Education] (2019). *Natur/teknologi. Faghaefte 2019*. https://emu.dk/sites/default/files/2020-09/Gsk_fagh%C3%A6fte_naturteknologi.pdf

Braun, V. & Clarke, V. (2008). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3* (2), 77–101.

Christensen, J. M., Jones, B., Cooper, J. R. McAllister, L., Ware, M. B. & West, R. E. (2015). International Journal of Technology and Design Education 2005–2014. *Educational Technology*, *55* (3), 36–42.

Department for Children, Education, Lifelong Learning and Skills [in Wales]. (2009). *Design and Technology. Guidance for the Key Stages 2 and 3*. Welsh Assembly Government. https://hwb.gov.wales/curriculum-for-wales-2008/key-stages-2-to-4/design-and-technology-in-the-national-curriculum-for-wales-guidance-for-key-stages-2-and-3/

Department for Education [in England]. (2013). *National curriculum in England: design and technology programme of study - key stage 3.* https://www.gov.uk/government/publications/national-curriculum-in-england-design-and-technology-programmes-of-study

Fahrman, B., Norström, P., Gumaelius, L., & Skogh, I.-B. (2019). Experienced technology teachers' teaching practices. *International Journal of Technology and Design Education*, *30* (1), 163–186.

Geim, A., Novoselov, K. (2007). The rise of graphene. *Nature Materials*, *6*, 183–191.

Inayatullah, S. (1990). Deconstructing and reconstructing the future: Predictive, cultural and critical epistemologies. *Futures*, *22* (2), 115–141.

[ITEA] International Technology Education Association [today known as ITEEA, International Technology and Engineering Educators Association]. (2007). *Standards for Technological Literacy*. International Technology Education Association.

Marshall, C., & Rossman, G. B. (2011). *Designing Qualitative Research* (5th ed.). Sage publishing.

Massachusetts Department of Elementary and Secondary Education (2016). *2016 Massachusetts Science and Technology/Engineering Curriculum Framework*. http://www.doe.mass.edu/frameworks/scitech/2016-04.pdf

Ministry of Education [in New Zealand] (2018). *Technology in the New Zealand Curriculum*. https://nzcurriculum.tki.org.nz/content/download/168478/1244184/file/NZC-Technology%20in%20the%20New%20Zealand%20Curriculum-Insert%20Web.pdf

National Council for Curriculum and Assessment [in Ireland] (2006). *Leaving Certificate. Technology Syllabus*. https://www.curriculumonline.ie/getmedia/da63d79a-b84f-4b8c-ba06-a4cb1fd21e07/SCSEC34_Technology_syllabus_eng.pdf

National Research Council [in the United States of America]. (2013). *Next Generation Science Standards: For States, By States*. The National Academies Press.

https://www.nap.edu/catalog/18290/next-generation-science-standards-for-states-by-states

Norström, P. (2015). Knowing how, knowing that, knowing technology. *Philosophy and Technology*, *28*, 553–565.

Roberts, D. A. (1982). Developing the concept of 'curriculum emphases' in science education. *Science Education*, *66* (2), 243–260. doi:10.1002/sce.3730660209

Roberts, D. A. (2007). Scientific Literacy/Science Literacy. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 729–780). Lawrence Erlbaum.

Scottish Qualifications Authority. (2012). *National 3 Design and Technology Course Specification (C720 73)*. Scottish Qualification Authority. https://www.sqa.org.uk/files/nq/CfE_CourseSpec_N3_Technologies_DesignandTechnology.pdf

SFS 1010:800 [The Swedish Educational Act, Sw. *Skollag*]. https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/skollag-2010800_sfs-2010-800/

Skolverket [The Swedish National Agency for Education]. (2024a). *Curriculum for Compulsory School, Preschool Class and School-Age Educare – Lgr 22.* Skolverket. https://www.skolverket.se/publikationer?id=13128

Skolverket [The Swedish National Agency for Education]. (2024b). *Sveriges officiella statistik. Elever på program redovisade efter typ av huvudman och kön* [Sweden's official statistics. Students per programme, sorted after gender type of school]. https://www.skolverket.se/skolutveckling/statistik/sok-statistik-om-forskola-skola-och-vuxenutbildning?sok=SokC&verkform=Gymnasieskola&omrade=Skolor%20och%20elever&lasar=2023/24&run=1

Skolverket [The Swedish National Agency for Education]. (n.d.). *Läroplan för gymnasieskolan*. Skolverket. https://www.skolverket.se/undervisning/gymnasieskolan/laroplan-program-och-amnen-i-gymnasieskolan/laroplan-gy11-for-gymnasieskolan

Utbildningsstyrelsen [The Finnish National Agency for Education]. (2014). *Grunderna för läroplanen för den grundläggande utbildningen 2014: Slöjd*. https://eperusteet.opintopolku.fi/#/sv/perusopetus/419550/vuosiluokkakokonaisuus/428782/oppiaine/530524

World Economic Forum. (2023). Future of Jobs Report 2023: Insight Report. https://www.weforum.org/publications/the-future-of-jobs-report-2023/in-full/