Technology in the HTX technology subject

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Abstract

The Danish higher technical examination programme (HTX) is the only high school program in Denmark that specialises in technology and engineering. Central to the curriculum are the profile subjects: Technology and Technical Science. In this article, we take a closer look at these subjects and examine the concept of technology embedded within them. The ministerial order regarding these subjects places the concept of technology within the 'Technology model'. We will examine the background for the model, its potential and limitations and the model's place in teaching through empirical findings to examine whether the Technology model lives up to its described purpose, which is to help the students fulfil the learning goals. Overall, it can be argued that the model works but also that the teachers should be aware of the model's shortcomings and discuss these with students, so they obtain a more dynamic and dialectical understanding of technology.

Teknisk Gymnasium (HTX) er den eneste gymnasiale uddannelse i Danmark, der har et stort fokus på teknologi og ingeniørvidenskab. Centralt i pensum på HTX er profilfagene: Teknologi- og teknikfag. I denne artikel ser vi nærmere på profilfagene og undersøger begrebet teknologi, og begrebet der er indlejret i dem. I bekendtgørelsen vedrørende teknologi- og teknikfaget placeres teknologibegrebet i rammen af 'Teknologimodellen'. Vi vil i artiklen undersøge baggrunden for teknologimodellen, dens potentiale og begrænsninger, samt modellens plads i undervisningen gennem empiriske fund for at blive klogere på, om teknologimodellen lever op til dens beskreve formål – at hjælpe eleverne med at opfylde læringsmålene. Samlet set kan der argumenteres for, at modellen fungerer, men også at lærerne skal være opmærksomme på modellens mangler og diskutere disse med eleverne, så de opnår en mere dynamisk og dialektisk forståelse af teknologi.

Technology in the HTX technology subject

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By Mette Møller Jeppesen & Lars Bo Henriksen, Aalborg University

Introduction

The Technical High School (HTX) holds a special place in the Danish secondary education landscape. It is the only form of secondary education specialised in technology and engineering. Central to the HTX curriculum are the profile subjects, Technology and Technical Science. Profile subjects are subjects that essentially define the type of education and the profile subjects technology and technical sciences distinguishes HTX from other forms of second level education. In this paper, we take a closer look at these profile subjects – Technology and Technical Science. More precisely, we want to investigate the 'concept of technology' in these profile subjects. That is, how is the concept technology understood – conceptualised – and which role, or roles, does this understanding play in both teaching and learning in the profile subjects (Henriksen, Nørreklit, Jørgensen, Christensen, & O'Donnell, 2004).

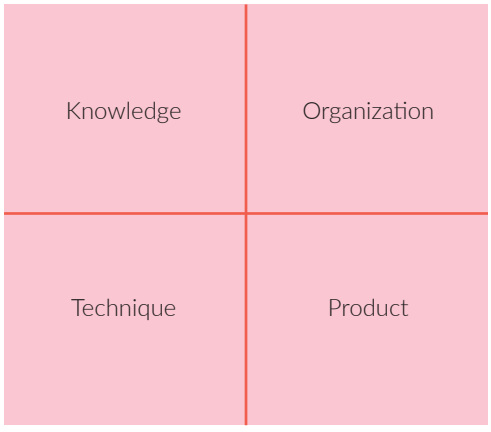
Exploring the concept of Technology in the profile subjects

In the curriculum for the technical high school (HTX) the concept 'technology' is described in sociotechnical terms:

> The subject technology deals with the connections between technological solutions and societal problems in a national and global perspective. The subject deals with technological innovation, that is, the development of products based on analyses of societal issues. In the interaction between technology, knowledge, organisation and product, social, technical, and scientific knowledge and knowledge are combined with practical work in workshops and laboratories.
> (Ministry of Children and Education, 2017, p. 1)

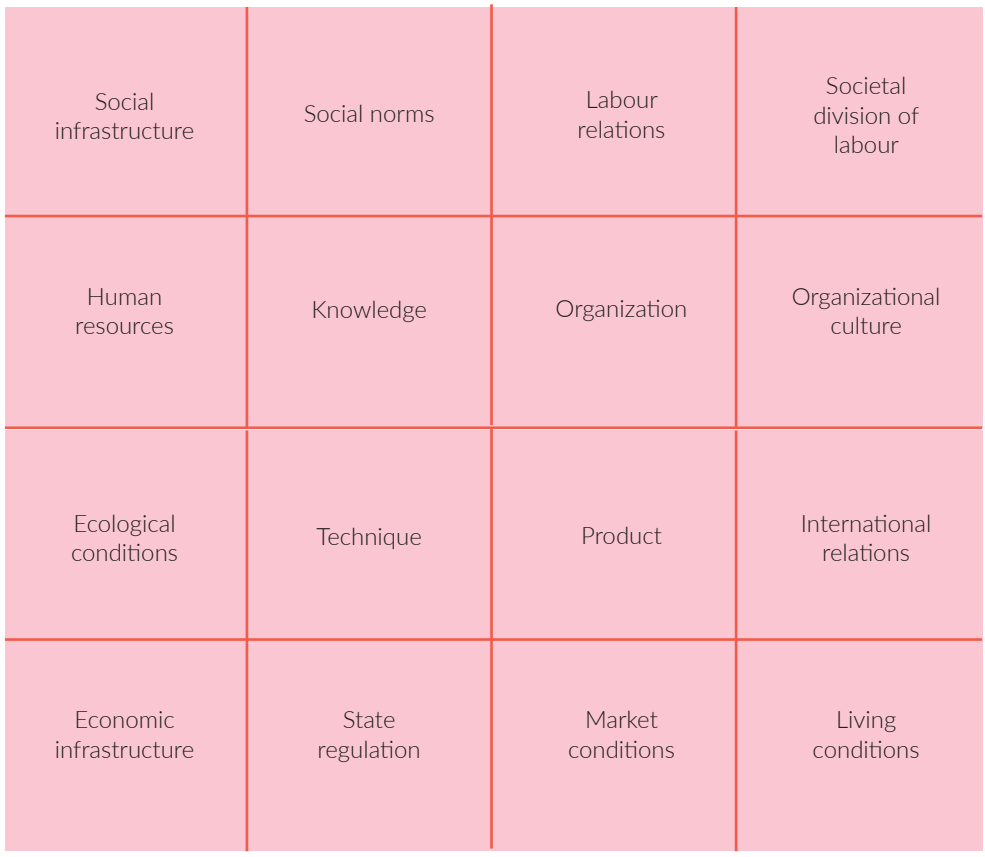
In the ministerial order the concept 'technology' is placed firmly within what is known as the 'Technology Model'. As stated in the ministerial order the Technology Model consists of four elements: technique, knowledge, organisation, and product (Figure 1).

Figure 1.
Technology.



These basic elements of the model can then be supplemented with other elements such as social infrastructure, social norms, human resources, etc.: this is the Expanded Technology Model (Figure 2).

Figure 2.
The Expanded Technology.



The Technology Model was developed and came to prominence in the 1980s and 1990s, especially at Aalborg University in the Technology and Society research group (Müller, 1980; Knudsen, 1983; Lorentzen, 1988; Müller, 1990; Lorentzen, 1994; and others).

Technique: Technique refers to all those tools, machines, and materials that combined with labour are necessary for the production process; in Marxist terms these are known as the instruments of labour (Müller, 1980, p. 20). The concept 'technique' is therefore restricted to what we metaphorically could term hardware and should not be confused with other uses of the term.

Knowledge: Knowledge refers to the software component, which is also necessary for the production process. Software is here used as a

metaphor and used in a wider sense as in computer software. It includes all the skills, intuition, insight, experience, tricks of the trade, and so on without which there could be no work or production process. This knowledge can be gained in several ways, in schools, in apprenticeships, through experience, or in any other way where one learns about the production process.

Organisation: In almost any process of production there is some kind of division of labour and because of this division we also need some form of coordination, or some form of organisation. This concerns the organisation of the production process itself, but also technology in its wider context. For example, roads and filling stations etc. for cars, rails and stations etc. for trains, airports and security control etc. for air travel. Organisation here refers to all relevant infrastructure necessary for making the world go around.

Product: The product element of the model refers to the end result of the production process. Most technologies aim to make a product as very broadly understood. In the case of the car, a plane, or a train we could say that the product is transport. In the case of the factory, it might be some kind of component. Therefore, the product is the final result we want to achieve when we use technology.

The Technology Model is a holistic model, which means that it attempts to describe technology as much more than simply products or things. The model also tries to capture everything it takes to make technology work the way we want it to work. In this way, the Technology Model can help provide us with a much more nuanced view of technology (Lorentzen, 1988, p. 22; Müller, Rimmen, & Christensen, 1986). These Technology Models have now found their way into the ministerial order and into several textbooks used in teaching or facilitating the technology subject at the HTX technical high school. The questions addressed here are therefore [1] which role does this model play at HTX, if any at all, and secondly, [2] is the model actually able or capable of fulfilling this role. The aim of the technology subject, as described in the ministerial order is to teach the students about the relationship between technology and society and the question is consequently whether the Technology Model is able to assist in achieving this goal.

The Technology Model gives us a much wider perspective on technology than other simpler models. One very prominent idea is that technology is applied science, stating that technology is developed based on scientific discoveries (Bunge, 1966). This, rather simplistic model, has been contested time and time again. Gil-Pérez, Vilches, Cachapuz, Praia, Valdés, & Salinas (2005), for example, argue that the

exact opposite is the case, that technology is necessary for science – Galileo needed his monocular and Boyle his air pump. Both conceptions of technology can under certain circumstances be correct. Today's advanced technologies are unthinkable without science and almost any scientific endeavour is based on some kind of technological device. However, both are too simplistic, and the Technology Models presented above are correct in the sense that they offer a much wider and more nuanced view on technology, especially when it points to the importance of the technological context, and much more than simply the device in question. Notwithstanding this widening of perspectives further questions arise. First, there is the question of the dynamics of technology. Technologies are developed, they are used by people, and they change over time. The Technology Model has no means of capturing this dynamic element. Instead, various studies rest on some, admittedly very interesting, narratives telling the stories of technological innovation and change (see for example, Lorentzen, 1988). But the model is basically a static model. Lorentzen (1988) attempts to remedy this by introducing a stage model for technological innovation (Lorentzen, 1988, p. 23), but this then falls into all the pitfalls of stage models. Building upon Edquist (1977) she states very rightly that 'technology is in itself a process', but then rather hastily suggesting a stage model beginning with phase one, basic research, and even if this should encompass all elements of the Technology Model and should be based on science, social science, and arts, it is doubtful if all technologies are based on basic research. The next phases are termed theoretical development (phase 2), application (phase 3), organisers, a phase where the end-users organise the technology into their everyday lives (phase 4) and finally, the use of the end product (phase 5). Questions could be asked of each of these stages, but a more basic criticism can be addressed. First, stage models have no way of explaining how one should get from one stage to the next, each stage is not very dynamic and overall, such stage models could be described as 'sequences of timelessness' (Henriksen, Nørreklit, Jørgensen, Christensen, & O'Donnell, 2004, p. 168). That is, even if it is presented as a dynamic model, it is not very dynamic, but still rests on empirical narratives in order to create the kind of dynamics needed.

A second question raised by the Technology Model concerns the relation between technology and the human actors involved. It is obvious that technology is man-made in the sense that no technology exists without some kind of human effort. This is implicit in the Tech nology Model. But what about technology's influence on us as users of technology? Are we not also affected by the technology? The world we live in is a very different place with technology or without technology (Ihde, 1990), and from ANT (Actor Network Theory) (Latour, 1987)

and STS (Science and technology studies) we have learned that technologies do have some form of agency; by agency here we mean that technologies are not neutral entities but are able to make us change our behaviours and our ways of acting in the world, and maybe also change our ways of thinking. In Heidegger's essay on technology, for example, he very convincingly argues that our way of thinking is strongly affected by technology (Heidegger, 1954/1977). He even calls the modern western worldview a technological worldview, meaning that we, as modern westerners, tend to think of efficiency as the ultimate goal and arbiter of almost everything. This view has potentially dire consequences for life on our planet, as we tend to think of everything in the world as material for our use, as objects for our manipulation and consumption, and to do that as efficiently as possible. If this is the case, then technology refers not only to manmade tools and means to an end, but also determines our thinking and our acting in the world, which is a very deterministic view. With this critical insight and with ANT's insistence on technology's agency, we can no longer be content with the Technology Model's four elements alone; we also need to more critically take into account the impact that technology has on us and on our ways of thinking.

We can now plausibly conclude that the Technology Model is an initial valuable contribution to the study of technology. It does not rest on simple explanations such as 'technology is applied science' or similar reductive definitions. Rather, it considers some of the complexities of technology. The question now becomes whether this is good enough in order for the model to function as a pedagogical and didactical device at the technical high school (HTX), given the missing dynamics of the model and its inability to show us, or reveal to us, the dialectical relationship between man and technology? In the remainder of this paper, we will take a closer look at the Technology subject and address the question of whether the Technology Model as it is laid out in the ministerial order is really capable of helping students fulfil the learning goals of the technology subject? In order to do so we will visit a class while it is being taught the subject of Technology to see how the Technology Model is taught to the students in the HTX classroom[1].

1 This visit was part of a larger action research project, over three years, and consisting of cooperation with the HTX teachers. The methods applied in the project could be described as participant observation, combined with interventions (see Jeppesen et al., 2020). The empirical data for this article were collected during several such interventions with a special emphasis on one observation where the teacher specifically addressed the Technology Model.

Teaching Technology

One enters the classroom at HTX in Aalborg and thirty students have already arrived and so has the teacher. The teacher starts by informing the students about the plan for today's lesson. First of all, the students are informed that the first one and a half hours of today's lesson is being completed as class teaching. Further, the teacher says the following:

> Today's lessons in this Technology A class deals with the concept of technology, the subject of technology, the technology report, and an introduction to an individual assignment.
> (Field notes, 05.02.2019)

All students in the class have to work with the Technology Model. The model consists of the four concepts noted in Figure 1 above: knowledge, technique, organisation, and product. The teacher has printed the model on paper and cut it out into small puzzle pieces. There are four pieces to the puzzle. Each student is then handed one puzzle piece each. They now have to conceptualise one concept depending on which piece of the puzzle they were handed. The teacher refers to one of the books used in the technology subject – preparatory material the students should have read at home before coming to class. They all get ten minutes to complete the assignment. Afterwards the students must form groups of four finding three other group members. One for each of the elements in the Technology Model. In these groups, the students now have to follow up on the concepts each of them just conceptualised in the previous assignment. Further, they, together as a group, have to attempt to conceptualise the concept of technology. Again, students are given ten minutes for the assignment. Some students leave to complete the assignment in the common area just outside the classroom; others stay in the classroom as it saves them time. Once the students have completed the assignment, they all gather in class. Here, the teacher and the students follow up on what the concept of technology contains, based on the concepts from the Technology Model: knowledge, technique, organisation, and product. The students conceptualised knowledge as being knowledge to make a product e.g., craftsmanship. Further, they argued that knowledge has to do with empirical findings, experience, creativity, and theoretical knowledge. Technique was described as the machines that are used to create products, materials, processes, and methods. They further found organisation to be management, division of labour, which can be both technical or societal and horizontal or vertical sub-processes. The last element of the Technology Model, product, the students con-

ceptualised as the end result of a manufacturing process, a physical product or service and as something having utility value or exchange value. Following a joint follow-up to the four concepts in the Technology Model, they now move on to talk about what technology is as a concept in relation to the technology subject. One student explains that the technology concept is about working with a societal issue, working with product development and working with the Technology Model. The student further adds that: "all parts are needed to create a solution" (Field notes, 05.02.2019). As the class finishes following up on the technology concept, the teacher gives the students a task. They must now discuss what the subject technology contains with the person they are sitting next to. The teacher further states that they must focus on the identity and purpose of the technology subject. In working with the subject, they must use the text they have read to prepare for today's teaching. The idea is for students to emphasise and highlight the most important passages in the text in relation to subject identity and purpose. After the students have completed the assignment, they are given a short break. One of the students has a birthday and has brought cake. When the break is over, they follow up on the identity and purpose of the technology subject in the class. Some of the points that are made about the identity of the subject include technological solutions, societal issues, local and global perspectives, problem-based learning, and innovative competencies. In connection with the purpose of the subject, they note that it creates prerequisites for higher education and teaches students to work independently and in collaboration with others. Before the class ended, the students had to work on each other's problem statements. Before starting, however, students get a checklist for a good problem statement. With the list in their hands, students now have to work on each other's problem statements to provide different suggestions on how to improve them. Among other things, they look at the form of the problem statement, whether there are sub-questions for the problem statement and whether it can be formulated more sharply. While the students are well into the assigned task, one by one the students find that the teaching is ending and therefore leave the room.

After observing how the Technology Model is taught in the classroom it is now interesting to see how the students actually manage to use the Technology Model in practice when doing project work. Before providing an example, it seems pertinent to provide the reader with some insight into what the Technology Model can be used for and how it is used.

What can the Technology Model be used for and how used?

When students in the technology subject write projects, they must also come up with a solution to the problem they are working on. They need to create a product. When thinking about the product, the students must also think about production preparation and for production preparation, the students can prepare a technology analysis based on the Technology Model (Jeppesen, Henriksen, Routhe, & Kristensen, 2020, p. 114-115). A technology analysis can be prepared at many different levels and which level is relevant to the project the students are working on depends on the problem they want to solve. Based on the four elements in the Technology Model, the students could analyse the elements through the following questions: the analysis of the knowledge element could start from the questions; what knowledge must be in the company to produce the product the students want to create? And what knowledge is there among the employees? And what new knowledge must the company acquire in order to be able to produce the student's desired product? (Jeppesen et al., 2020, p. 115). The technique element could be accessed through questions such as: which processes in relation to the manufacturing process should be manual and which should be automatic? Are there new work processes? And what new production plants are needed? (Jeppesen et al., 2020, p. 115). In relation to the organisational element of the Technology Model, this element can, among other things, be unfolded through the following questions: Are there any new professional groups to take care of? And how is the readiness/capability to switch from one product to another? The final element, the product element, can also be accessed by looking at: "how the production process should proceed, what opportunities and barriers exist with the product, the environmental aspects, economics, and marketing etc." (Jeppesen et al., 2020, p. 115). It is a questioning, challenging, collaborative, and dynamic thinking process.

How can the Technology Model be used in practice?

Now that we have gained some insight into how the Technology Model is taught in the technology field at HTX and have gained some greater insight into what the Technology Model can be used for and how, we now look at where the students actually use the model in practice.

The technology analysis is carried out for the production preparation together with a detailed documentation of the manufacturing process (Jeppesen et al., 2020, p. 115). Not all students use the Technology Model in their projects, nor is it an essential requirement. However, it is applicable in most Technology subject projects at HTX. Every time the students start a new technology project they must evaluate which methods can best help them to answer or address their problem statement and through this evaluation of methods, the Technology Model and thus also the technology analysis ends up being part of the methodological approach chosen.

When this is the case, the Technology Model is used to perform a technology analysis based on the physical product the students wish to create as a solution to the problem they are working on. The students are very structured when they use the Technology Model to perform a technology analysis. They base the analysis on the four elements: technique, knowledge, organisation, and product and through one element at a time analysing and thinking their way through the model asking the abovementioned questions. Table 1 below illustrates the structure of a technology analysis, the four elements of the Technology Model, as well as the sub-topics that students need to complete when performing such an analysis.

Table 1.
The Expanded Technology.

Knowledge			Organisation		
Ability	Insight	Intuition	Manage-ment	Coordi-nation of work distribu-tion	
Technique			Product		
Work Mens	Work Items	Labour	Type of product	Does the product have utility value?	Does the product have trade-in value?

Although the method is relatively simple and straightforward to apply, it is still possible to complete the individual elements more or less specifically. Below are several examples taken from the empirical findings of how the various elements of the Technology Model can be filled in, or completed, very differently.

Example 1.

Knowledge		Knowledge
Ability		Ability
Handling of jigsaw or painting.		Experience knowledge is based on a previous workshop course. During the course it was learned how to work in the workshop and how to use the machines. Experience is further drawn from previous projects and in addition we have also been able to expand our experience by asking the supervisor for advice on specific issues.
Box 1		*Box 2*

In the above-mentioned example, it becomes clear that there are some differences in how students unfold the different elements of the Technology Model. Box 1 shows an example of students who have described only practical skills, such as the practical skills that the students in question have possessed prior to project work. What they already know. In contrast, Box 2 describes how the students concerned both draw on existing experience, but further, it also notes that they are aware that they draw on experiences from previous projects and that, in addition to this, they have the opportunity to draw on even more knowledge from their supervisor. Here the students are thus able to illustrate that they understand the project design process and that they additionally understand how to incorporate this knowledge into the technology analysis.

Example 2.

Technique		Technique
Labour		Labour
Human labour and the machines used.		Several different machines have been used, all of which have been handled by the same person. In addition, some special machines were also used for the processes in product development that required it.

Box 1 *Box 2*

In Example 2 similar differences are noticed. In Box 1, the students in question write very short and specific notes on the workforce in their project. Human labour and machines have been used. In contrast to this in Box 2, it is illustrated that some students describe in some more detail how labour relates to their project. It is noted who handles the machines and that special machines have been used for specific processes in the development process. Again, different ways in which the elements of the Technology Model can be completed and thus the technology analysis can be unfolded are illustrated here. The students are able to illustrate that they understand the process in which they are working and in addition how to incorporate this knowledge into the technology analysis. It is emphasised again that there are students who are able to illustrate that they understand the process that is part of the project work and at the same time that they are able to draw that knowledge into the technology analysis.

Example 3.

Box 1	Box 2
Organisation	Organisation
Coordination of work distribution	Coordination of work distribution
Joint management of the project and work has been carried out vertically.	Work has been done on both horizontal and vertical work distribution in the project. Horizontal in the sense that tasks are distributed among the group members so that it has been possible to work on several tasks at once. Vertically in cases where important joint decisions must be made that are important for the project work.

The final example, Example 3, supports the previous two. It seems that there are basically two ways to fill out the elements of the Technology Model and thus to carry out the technology analysis. Either writing very short and specific notes or writing and being conscious about drawing on experiences from previous lectures, other projects etc. This is also illustrated in Example 3 above where it is seen in Box 1 that the students in question very briefly noted that they had a common coordination of the work distribution in connection with the project and that all work distribution was done vertically. Box 2 shows the opposite example that some students have made some deeper reflections on how they have coordinated and distributed the tasks in project work. Here it is specified that the students concerned have worked with both vertical and horizontal distribution of work and also how it was applied in their project. In addition to the technology analysis based on the Technology Model, when the product is complete, the students can prepare a technology assessment to assess how the new technology they created interacts with the rest of the community (Jeppesen et al., 2020, p. 115).

Conclusion

In this brief paper, we raised the question about the role of the concept of technology in the HTX upper secondary school, especially in the Technology subject. From the ministerial order we found that the so-called Technology Model is written directly into the legal basis of such education. The question addressed here was therefore which role this model plays at HTX, and secondly, if the model is actually able to fulfil this assigned role. From the above analysis of the Technology Model, we found that the model is comprehensive and much more holistic than models describing technology as applied science or similar reductive models. We also found that the Technology Model lacks a dynamic focus, and it is not clear how the Technology Model handles the impact technology might have on us as users – how it critically affects our ways of thinking and acting. We also saw how it is taught, how the teachers could use it, what it can be used for in the classroom and how it can be used in student projects and assignments. From all this, we can reasonably conclude that the model works. With the model, students have access to a design of a technology analysis based on the technology they have developed in their projects – and for such a purpose the model seems excellent. However, the use of the model can also be problematic in the sense that it can be used very 'mechanically' by the students. For some of the students, the use of the model becomes more a question of filling out the boxes in the model, so that they can say that this part of the project has been completed. Therefore, in some cases it may also function as a checklist more than a model. HTX teachers need to be aware of this, and to make sure that this problem is addressed in classroom discussions. The model may be further problematized as not including a more comprehensive understanding of technology and therefore not enabling the students to relate to how the technology they have worked on in the project affects both the students themselves and the context in which they are included. But perhaps this would be too much to ask at an upper secondary level. Overall, however, it can reasonably be argued that the model works. It aims to help students to complete a technology analysis. But it can also be argued that HTX teachers need to be aware of the model's shortcomings and discuss this with students so that they obtain a more dynamic and dialectical understanding of technology.

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