Technology Teachers' Perceptions of Models in Technology Education

Björn Citrohn and Maria Svensson

In this study we investigate how 11 Swedish technology teachers perceive the use of models in technology education. Models are part of technology education in many countries even though there are few studies investigating teachers' understanding of models as part of the subject and how models are used in education. The use of models and modelling in technology is connected to problem solving and builds on both practical and theoretical knowledge. Models could be understood as both cognitive and physical, used for describing complex artefacts and solutions as well as working with developing solutions. Our study involves empirical interviews with technology teachers, teaching technology and science in grade 7-9 (pupils 13-15 years old). By using a content analysis, we explore how teachers perceive the use of models in technology education. The analysis resulted in two themes and five different categories used to understand how teachers perceive models. When comparing with the dual nature of models (Nia & De Vries, 2017) the Swedish technology teachers mainly relate the use of models to an intentional nature. This indicates that there are model functions that the technology teachers do not perceive at all or only perceive to a limited extent which could have a negative effect on the possibilities for pupils to understand and learn about complex technological relationships and phenomena, as well as for pupils' ability to solve problems.

Keywords: Models, Dual nature of models, Technology education, Technology teachers

Introduction

There are some studies that investigate models in relation to the subject technology. One such study is a case study from the US examining how models have been used in the documents that describe standards for technological literacy (Nia & de Vries, 2017). This study identified that technological K-12 students need to be acquainted with different functions of models to understand the meaning of models in technology. When related to philosophy of models and previous research on models, a framework describing *the intrinsic* and *the intentional* nature of models, the dual nature of models, became the result. The intrinsic nature of models describes the material structure of models and different types, or forms, of models. The intentional nature is more about the usage of models, for example supporting development of knowledge and products and communicate about knowledge and products. The dual nature of models was derived from philosophical discussions about technical artefacts as having both a physical-structural and intentional nature (Kroes, 2010). Technical artefacts are the outcome of human intelligence and physical work and in that way technical artefacts are relational entities (Meijers, 2001).

Nia and De Vries (2017) argue that considering models as techno-scientific artefacts contributes to the technological literacy of pupils who are expected to learn about design and make models. They emphasize that the dual nature of models proposes a "well-structured reference enabling teachers to speak of various aspects and properties of models through a methodically-categorized approach" (Nia & De Vries 2017 p. 649). The dual nature constitutes an important framework for our investigation of how technology teachers perceive models.

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Models are often described as mental or cognitive models and as physical or expressed models (see e.g. Gobert & Buckley, 2000; Gilbert, 2004). This separation, in cognitive and physical models, have a potential when analyzing and describing models, but often existing as intertwined and dependent on each other. The cognitive models are internal cognitive representations used to generate external representations for reasoning (Gobert & Buckley, 2000). Regarding models in technology an important aspect, highlighted in research, is what distinguishes technical artefacts from natural objects. The former is influenced by man, while the latter has only been influenced by nature. A model can therefore be considered as a technical artefact, a deliberately constructed object that shows its function through its physical properties and possibilities (Weisberg, 2007; Knuuttila, 2005).

The Swedish technology curriculum (Skolverket, 2018) differs from other countries, when it comes to models and the use of them. A study comparing the Swedish curriculum with the Irish, New Zealand and South African ones regarding the way to express models, explicit or implicit, shows that the Swedish curriculum is quite implicit regarding models and the use of them (Citrohn 2018). An interesting question is what effects the implicitly of models in the Swedish curriculum have and if there are any connections to the identified focus on the doing without reflection in technology education in Sweden (Skolinspektionen, 2014). Studies show that the interpretations of the curriculum, that teachers do in combination with their choice of content, affect what pupils are offered to learn in technology (Bjurulf 2008). Irish researchers have, in the same way as in Sweden, noticed a focus on the design of the product instead of the process (Lehay & Phelan, 2014).

Method

We are interested in technology teachers' understanding of models in technology education and want to answer the question, *How do technology teachers perceive the use of models in technology education?* An appropriate way of investigating this is to use a qualitative method that gives us the possibility to do in depth interviews with teachers about models. We have analysed the transcribed interviews using a content approach. The content approach is a qualitative analytic method that is flexible and can provide rich and detailed data. The purpose with a qualitative content analysis is to analyse text data. Research using qualitative content analysis (Hsieh & Shannon, 2005) focuses on the content or contextual meaning of the text from different sources such as transcribed interviews. In the analysis the researcher allows the categories and names for categories to appear from the data, an inductive category development.

The process started with the creation of semi-structured interview questions and testing them in a pilot interview. Evaluation of the transcript from the pilot interview resulted in some adjustments of the interview questions. The interviews, all in Swedish, were preformed and audio recorded via ZOOM, an internet-based video conference system, by one of the authors. Afterwards the recordings from the interviews were transferred into MAXQDA, a data analysis software, and from there they were transcribed in Swedish. The transcripts were read thoroughly to find patterns linked to the teachers' use of models with the content analysis as a guiding principle. Tentative patterns were identified and described as themes with their own categories. After trying the themes on research colleagues, to get a broader perspective of the interpretations, the transcripts were revisited and the themes were reviewed; this was repeated several times and during the process. The whole process ended in two themes, one containing three categories and the other containing two categories.

The interviewed teachers

The data that this study builds on, has been collected through interviews with 11 technology teachers (T1 to T11). The teachers had all a certificate in technology and were experienced (more than 10 years) technology teachers. They were spread geographically from the north to the south of Sweden and were active as technology teachers at the time of the interview. Four of them were working in private schools

and seven were working in public schools. Besides teaching technology most of them had a combination that included math and physics, one of the teachers had a combination with art. Some of the teachers had both a teacher and an engineering degree.

Results

The analysis of data resulted in two themes in which the teachers perceive models as; *A tool for communication* and *A tool in the design processes.*

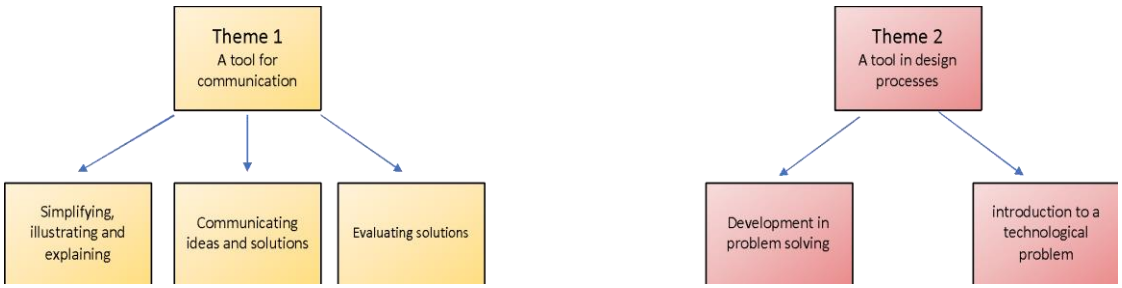

Figure 1. Overview of results from the content analysis

Theme 1 - A tool for communication

In this theme, teachers perceive models as a tool for communication. The theme is about simplifying, illustrating and explaining, presenting technological solutions, and models as a tool for evaluating solutions. Models are used by both teachers and pupils for communication, it is a way to create a common language, a tool to express thoughts about technical solutions, so that others can interpret them.

Within this theme three different categories are identified describing models as a tool for communication:

a) Simplifying, illustrating and explaining

b) Communicating ideas and solutions

c) Evaluating solutions

a) Simplifying, illustrating and explaining.

To simplify, illustrate and explain the function, appearance and structure of an object or system, are essential parts of technology knowledge. The teachers perceive the model as a tool to make things more understandable for the pupils. Very often this includes making an image or a mock-up of reality in order to create an understanding of function and context. Reality is usually presented in a smaller scale, to easier get an overview.

> Often we use models to simplify or explain something, so that it becomes easier to understand (T11)
>
> A model shows something, often quite complicated, which you can show in miniature format so that it can be seen more orderly. (T11)

Sometimes it is about objects or systems from reality, that are difficult to display in a classroom. In such cases a model can play an important role to facilitate pupils' understanding. For the teacher the intention often is to make the pupils aware of functions in objects and systems, in an accessible way.

> Usually, it is about wanting to portray or show something that I cannot bring into the classroom. Either that it is too big or dangerous or something like that, and then I need some type of model that can show the function to the pupils. (T3)

b) Communicating ideas and solutions

In order to communicate ideas and solutions, a model can be a tool, according to the teachers. In a first stage, when pupils present their ideas, sketches or drawings and in a second stage these models are developed to a physical model that further strengthens the presentation.

> On the other hand, a drawing is a part of the model from which I can build a model, from one model to another, one might say. (T1)

An important skill for pupils is to be able to communicate their decisions during the design process and to present their solution as a model. The model facilitates both for the person who presents their solution and the person who listens to the presentation so that they could easier create cognitive models. The interviewed teachers use exhibitions of models and collaborations with companies, where the pupils can take part of each other's solutions and present their ideas in an authentic context.

> Models are a way for us to speak in common language, so that we understand each other. It is not so easy to interpret what a person is trying to express from his head. But when we start working with models, we can cooperate, understand and approach something that we have in common. (T11)

> Then they were commissioned to improve an existing or find a new product for the company and build a model of it. Thus, a drawing and build a model of it and present their thoughts to the company's management. That was among the best we have done. (T5)

c) Evaluating solutions

Finally, the teachers see models as a tool for evaluating solutions developed in problem solving processes. The category is about comparing the solution with the requirements (e.g. its purpose) not about testing the actual product, which is a part of our second theme. Evaluation of a model can be seen as a cognitive process that is useful for the pupils as they evaluate their own solution in relation to the requirements and to other pupils' solutions.

Several teachers also emphasize the importance of models as a final product for assessing pupils' knowledge development in technology.

> Why is that solution best? What was it like … what did they do to make it better? For me, as a teacher, this is a very important part of the work with a solution. (T9)

Summary theme 1

Theme 1 displays that the interviewed teachers' perceptions of how models are used in technology education, is to be able to communicate about technological solutions and artefacts. Using models with an intention to better understand, physical models as well as cognitive models. This way of using models has connections to the intentional nature of models described by Nia and de Vries (2017) as supporting development of and communication about knowledge and products. We interpret it as teachers enhance pupils' understanding of how to use models when they present ideas during the development process and to present the final solution. In this way models could be understood as *Procedural Models* – a model is used to communicate the final product in a design process and *Decisional Models* – a model is used when taking a decision regarding the final product (Nia & de Vries, 2017).

Theme 2 –A tool in design processes

This theme describes teachers' use of models as part of the design process where physical models are in focus. In this theme models are perceived as something that could be used when introducing the design process and/or a problem-solving activity. Several teachers describe problem solving skill as an important ability in the subject technology with opportunities to present various solutions of a problem

and to evaluate and reconstruct a solution. Within this theme two different categories are identified describing models as a tool in the design process:

a) Introduction to a technological problem

b Development in problem solving

a) Introduction to a technological problem

Models can be used to trigger the pupil's thoughts and give them inspiration for problem-solving. The teachers emphasise the importance of using former pupils' models as inspiration, as a possible and realistic example and as an expected outcome, to avoid that they only copy a "perfect" model.

> I'd rather take old pupils' works. If I show something I have done, everyone wants it to be the same. So, it is not always good to show things that are too perfect. Because there are always pupils who wants to do the same, and it inhibits their imagination. (T11)

Another way to use models when introducing a problem is to collaborate with companies letting them describe a problem by using a model. This makes pupils more engaged and inspired and also makes them better understand the purpose of the model and the context for the problem.

> They get an idea from the company, a basic task: Can you help us improve the following? So, they got different assignments and then they started reading, they had to have contact with these companies and sketch on an idea. It should be both their thoughts in writing and drawing and then building a model. Finally, it was presented. The pupils are incredibly motivated… (T6)

b) Development in problem solving

According to some of the teachers in this study, the opportunity to test and change the models during the problem-solving process is of importance. The model used for testing should be built in a changeable material. Testing is strongly associated with improving function, materials and structures in the solution to meet the requirements. A benefit with a physical model is that it enables the use of more senses when it is evaluated, which is not the case with cognitive models.

> We have worked a bit with disability aids of various kinds. In fact, the models have been important for testing ideas. If it really is an idea that works at all. They try to visualize their thought processes by using a model. (T11)

As mentioned in Theme 1 models can be used for communicating thoughts and ideas but teachers also talk about trying and retrying, trial and error as a practical process that reinforces both cognitive and tactile understanding. The model that is created is not really the important thing, but the process to create it.

> It is more the process, the actual product is really not that important, it is the journey and what they do while they are building the model which is important. (T10)

Summary theme 2

In theme 2 the teachers perceive that models are used to inspire and engage pupils in technological problem solving and for testing their ideas. When using models for introducing technological problems we interpret it as a form of communication but with a clear connection to the design process. We also interpret that the teachers perceive the use of models as connected to practical work with a focus on physical models. In this way this theme also relates to the intentional nature concerning development of, and communication about knowledge and artefacts (Nia & de Vries, 2017). We interpret this as the teachers' use of models mostly as *Decisional Models* helping pupils to better understand possibilities and limitations with a solution.

Discussion

The teachers in this study use models mainly to communicate about technology solutions in different situations; they do not use models to support development of artefacts when building and manipulating. In relation to Nia and de Vries' (2017) framework our results highlight the teachers' awareness of the use of models in technology but also their lack of awareness about the opportunities with using models in technology education. They do not use models for learning procedural knowledge and develop and taking decisions in the design process. As technology teacher it is important to understand the dual nature of artefacts (Kroes, 2010; Meijers, 2001) to create a solid foundation for their own understanding of technology and thus be able to contribute to pupils' learning about technology.

The connections between our results and the *intentional* nature is strong concerning communicating about knowledge and artefacts, but on the contrary the connection to the *intrinsic* nature of models is weak. In that way pupils do not become acquainted with the material structure of models and various types of models. Taking into account that the Swedish national curricula in technology are implicit regarding models (Citrohn 2018) the presumptions for teachers when working with models are problematic. Further studies and investigation about the use of models in technology education are needed. The next step is to better understand how teachers use models by investigating their perceptions of model functions using a directed content analysis and also the influence of teachers educational profile.

References

Bjurulf, V. (2008). *Teknikämnets gestaltningar : En studie av lärares arbete i skolämnet teknik* (PhD dissertation). Karlstad University studies, Karlstad. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:kau:diva-24190

Citrohn, B. (2018). *Modeller i teknikkursplaner: En jämförelse mellan några olika länder* (Dissertation, Linköpings universitet, Institutionen för samhälls- och välfärdsstudier). Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-162257

Gilbert, J.K. (2004). Models and Modelling: Routes to More Authentic Science Education *International Journal of Science and Mathematics Education* 2:115 doi:10.1007/s10763-004-3186-4

Gobert, J. D. & Buckley, B.C. (2000) Introduction to model-based teaching and learning in science education, *International Journal of Science Education*, 22:9, p. 891-894, doi:10.1080/095006900416839

Hsieh, H.-F., & Shannon, S. E. (2005). Three Approaches to Qualitative Content Analysis. *Qualitative Health Research, 15*(9), p. 1277-1288. https://doi.org/10.1177/1049732305276687

Knuuttila, T. T. (2005). *Models as Epistemic Artefacts: Toward a Non-Representationalist Account of Scientific Representation*. (Philosophical Studies from the University of Helsinki; No. 8). Vantaa: Edita Prima.

Kroes, P. (2010) Engineering and the dual nature of technical artefacts. *Cambridge Journal of Economics*. 34, p. 51-62. doi:10.1093/cje/bep019.

Leahy, K., Phelan, P. (2014) A review of Technology Education in Ireland; a changing technological environment promoting design activity. *Int J Technol Des Educ* 24, p. 375–389. https://doi.org/10.1007/s10798-014-9266-z

Meijers, A. W. M. 2001. The relational ontology of technical artefacts, in Kroes, P. A. and Amsterdam, M. A. W. M. (eds), The Empirical Turn in the Philosophy of Technology Research in Philosophy and Technology, Vol 20, (series editor Carl Mitcham), Amsterdam, JAI/Elsevier

Nia, M.G. & de Vries, M.J. (2017). Models as artefacts of a dual nature: a philosophical contribution to teaching about models designed and used in engineering practice. *International Journal of Technology and design education* 27:627–653. Retrieved 2020 March 31 from https://link.springer.com/content/pdf/10.1007%2Fs10798-016-9364-1.pdf

Skolverket (2018) , *Curriculum for the compulsory school, preschool class and school-age educare, Revised 2018*, Retrieved 2020 March 31 from https://www.skolverket.se/getFile?file=3984

Skolinspektionen (2014) *Teknik-gör det synliga osynligt. Om kvaliteten i grundskolans teknikundervisning* (Rapport 2014:04) Stockholm. Retrieved 2020 March 31from https://www.skolinspektionen.se/globalassets/publikationssok/granskningsrapporter/kvalitetsgranskningar/2014/teknik/kvalgr-teknik-slutrapport.pdf

Weisberg. M. (2007) Three Kinds of Idealization. *Journal of Philosophy* 104 (12), p. 639- 659 https://doi.org/10.5840/jphil20071041240

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