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What kinds of variation are made available in technology education?

Five teachers from the Swedish compulsory school were interviewed about technology and technology as a subject in school. One field of work for each of the teachers was observed. The analysis is under work based on the variation theory. The aim of this paper is to present what kinds of variation that are made available in *two* teachers' classrooms. Examples from the data show that there are different kinds of variation in John's[1] and Gustav's teaching, but one kind more frequent than others. In Gustav's case the "principle-apply variation" is most common, which means that there is a fundamental idea needed to be understood by the students, for them to be capable to make suitable choices and/or acts. In John's case the most frequent kind of variation is the "example variation". It means that the examples of a specific aspect vary. Interesting to discuss is how these results affect the shape of the technology subject in the two teacher's classrooms.

Introduction

Technology is a rather new subject in the Swedish compulsory school, while considering it has had a syllabus for only about 10 years. To evolve the subject, there is a need to know how it is practised in different classrooms. This paper focuses on: What kinds of variation are made available in technology education in the classrooms of two teachers? The paper is a part of ongoing research.

Research on technology and teaching

Several research surveys have been done in the field of technology and in relation to education (de Vries, 2003; Petrina, 1998; Zuga, 1997). These surveys show that most of the research has focused on curriculum and other official documents for teaching in technology. In a few cases the surveys concentrated on teacher's teaching or what the students actually learned. The authors call for research concerning what is going on in the classroom and the teacher's actual teaching.

With reference to what teachers are teaching and how they construct the subject there is some research available. Different subjects have been in focus such as history and physics (Patrick, 1998), business administration (Rovio-Johansson, 1999), mathematics (Runesson, 1999) and the life cycle of angiosperms (Vikström, 2005). Common for the conclusions of these studies are that the teachers involved use the same curriculum and syllabuses and teach the same object of learning, but the students meet different content. It can be summed-up as the teachers' understandings of a subject have influence on their teaching.

[1] The names of teachers and students in this paper are fictive.

Theoretical framework and method

The theoretical framework in my study is the variation theory, which has developed during the last ten years. It is a learning theory that examines the consequences of teaching, based on the three concepts discernment, variation and simultaneity (Marton & Booth, 1997). In my work it is the intended and the enacted object of learning that is in focus (see Marton, Runesson & tsui, 2004, p. 4). Earlier studies have shown that teachers teaching the same learning content offer students various possibilities of understanding depending on how the learning content is dealt with (Marton & Morris, 2002). Determining factors were what teachers focus on during lessons, what varies, what varies simultaneously and what is kept constant.

Discernment, Variation and Simultaneity

In this section I will explain my understanding of the fundamental concepts of the variation theory.

We are always aware of a number of things, but not in the same way and not at the same time (Marton & Booth, 1997). Some aspects can be in the foreground and others in the background. If we are not aware of an aspect we can say that the aspect is absent or taken for granted (ibid.). In order to discern something in a certain way variation is necessary and there is no variation without simultaneity and no simultaneity without discernment (Marton & Pang, 1999). Logically these concepts are related to each other and essential for experiencing a particular aspect of a phenomenon.

Runesson (1999) puts it: "to know what something is, you have to know what it is *not*" (p. 31). Every discerned aspect has to be related to the fact that it could be in a different way, and identified to discern it from its context at all (ibid.). It can be compared with the opposite heavy-easy, high-low and so on.

To discern something in a particular way we must discern features and relate them to something else. The simultaneity concept gets its definition when different aspects are discerned simultaneously. To discern a wagtail as a small bird presupposes that it must be compared to a swan or an eagle for example. On the other hand the wagtail is a big bird compared to a humming-bird. Such discerned aspects, as the size in the bird-example, constitute values in experienced dimensions of variation. Marton, Runesson & Tsui (2004) distinguish between diachronic simultaneity and synchronic simultaneity. Diachronic simultaneity is the simultaneous experience of different instances at the same time and synchronic simultaneity is the experience of different co-existing aspects of the same thing at the same time. Both kinds may occur in a classroom context. Furthermore in a classroom context students and the

teacher probably discern different things. There is no guarantee that the students learn what the teacher has intended with the lesson, but what teachers *can* do is to create possibilities for students to learn something in some way. From this perspective it is interesting to study what aspects teachers are focusing on, which is a part of what is possible for the students to learn.

To understand what is or not is possible to learn in a specific situation we need to pay attention to what varies and what is invariant or constant (Marton, Runesson, & Tsui, 2004). Marton et al. mean that variation in general does not enable better possibilities to learn, but variation that enables learners to experience the features that are critical for a particular learning:

> It is necessary to pay close attention to what varies and what is invariant in a learning situation, in order to understand what is possible to learn in that situation and what not. (p. 16)

Runesson and Mok (2004) give the example of the critical features from a square: the size of the angles, the number of sides and the relations between them. The critical features vary with different learning objects and have to be discerned for each one. The critical features also vary between different groups of individuals. Learning to understand and handle a particular object of learning involves discerning its critical features (critical in relation to a certain aim) and focus on them simultaneously. The features must be experienced as dimensions of variation. This means there are different values that can vary within a dimension of variation.

To study learning from a variation theory perspective previously meant studying teachers teaching the same learning object. Patrick (2002) means that such episodes can be looked at from a broader perspective, by seeing how study of the discipline itself is constituted for students:

> The analysis of variation presented in Runesson and Marton (2000)[2] focused on the teaching of particular concepts introduced in particular teaching episodes. I argue that we can look at such episodes from a broader perspective, to see how the discipline itself is constituted for students. What kinds of variation are made available? And what are excluded? How does this affect the student's apprehension of what is involved in the study of the discipline? (Patrick, 2002 p. 95)

Dahlin (in press) is of a similar opinion as Patrick and suggests that if a limitation is made just to study variation and critical aspects when teachers and students are working with a delimited learning object, there is a risk of

[2] Marton, F. & Runesson, U. (2000) *The space of learning.* Paper presented at the New Phenomenography workshop, Hong Kong, July.

overlooking what he calls possible implicit learning objects. With this understanding in mind there are implicit dimensions of variation for all learning objects related to different conceptions of the subject as such. The teacher may have a broader knowledge of the learning object that she or he takes for granted. This taken for granted awareness can be both reflected and unreflected. Dahlin means that the implicit learning object is not so much about the specific content of the subject, but about the subject more generally. Irrespective of what the teacher and the students are working with in the classroom there may be a limitation of what is possible to learn as a consequence of what the teacher is focusing on, what is varying and what is varying simultaneously. The learning object may differ and yet the understanding of the subject as such as constituted by the students may be the same.

The study presented in this paper is analyzed by applying the concepts from the variation theory, but in the broader perspective as Patrick and Dahlin suggest.

The sample

In the spring of 2004 a questionnaire was sent to 123 technology teachers teaching grade 7-9 (13-15 years old students). I received 99 questionnaires in return, after two reminders, and 29 teachers had marked their interest in participating in the continued study. Five teachers were contacted by phone and visited at their place of work during the spring of 2004. The teachers selected had answered in the questionnaire that they utilized the time during the technology lessons in different ways, in relation to practical work, social or historical perspectives, combined with a great amount of education in technology. This way of sampling is described by Cohen, Manion and Morrison (2000) as a purposive sampling.

Data collection

The five teachers in the study were interviewed twice, i.e. before and after an observed field of work. The first interviews lasted 40-60 minutes and the second ones for 10-20 minutes. The interviews were all transcribed by the author. The interviews can be referred to as semi-structured (Cohen, Manion, & Morrison, 2000) since the teachers had great freedom to discuss what they wanted, regarding the point of departure in some questions and within the scope of technology.

I observed one field of work for each teacher. The lessons were videotaped and constitute about 50 hours of recording. The teachers were also recorded on a tape recorder attached to their belts. The data was transcribed where the audio tapes were the point of departure complemented by the videotapes. Table 1 is an overview of the data collection.

Work in progress – May not be cited

Table 1 The table shows when the observations were conducted. All data applies to year 2004. The table shows both numbers and the total time of the observed lessons.

	August	September	October	November	December	Number	Time(h)
Gustav	1	3	3	2	1	10	13,3
Marie		11	2			13	13
Alfred				4		4	3,7
Alva				4	7	11	10,5
John				9	1	10	10
Total number and time of observations:						48	50,5

All data recorded is selective (Hammersley, 2003). There are more things going on in a classroom than are possible to record. As my research question concerns the teachers, I followed them with the camera documenting their work in interaction with the students. In this paper the preliminary results from two of the teachers' teaching are accounted. A limitation is thus made to the observations in the classrooms. Here follows an overview of each of the two observed fields of work. The shaded fields indicate that *some* student works with the actual task at the specific lesson.

Gustav taught 15 students in grade 9 (15 years old). Ten lessons were observed and they all lasted 80 minutes. Gustav called the field of work *Handy at home.* Table 2 presents all tasks included.

Table 2 Disposition of lessons within the theme "Handy at home" in Gustav's teaching

Content	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8	Lesson 9	Lesson 10
Apartment drawing										
Circuit diagram										
Electric cable										
Build a brick wall										
Paper a wall										
Windpower station										
Hook on a wall										
Test										
Evaluation										

Table 2 shows that several tasks were in progress at the same time, especially from the fifth lesson and further.

John taught 17 students in grade 7 (13 years old). Ten lessons were observed and all lessons lasted 60 minutes. John called the field of work *Transports*. Table 3 presents all tasks included.

Tabell 3 Disposition of lessons within the theme "Transports" in John's teaching

Content	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6	Lesson 7	Lesson 8	Lesson 9	Lesson 10
What is technology?										
Technology history										
Valuation exercise										
Build a vehicle										
Write a report										

Table 3 shows that the field of work proceeded through work with one task at a time.

Data analysis

There were several tasks in progress during the fields of work (see tables 2 and 3). I analyzed every single task through following procedure:

1) What did the teacher focus on concerning the specific task?

With focus means what the teacher said or showed in a whole class presentation or what he repeated at several occasions, when the students worked individually or in groups. For every single task the focused aspects that constituted dimensions of variation became points of departures for the continued analysis.

2) What was varying, i.e. what *kind* of variation was it?

The different dimensions of variations were analysed with reference to what kind of variation they represented.

Totally there were 5 categories in the two teachers' teaching: *material variation, example variation, gradation variation, principle-apply variation* and *function variation*. In

the following the different categories are described, with attention to their characteristics. The categories are exemplified with quotations from the data. After the description there is an account for the distribution of the kinds of variation in Gustav's respective John's teaching. The paper ends with a discussion and conclusion about how the results affect the shape of the technology subject in the two teachers' classrooms.

Kinds of variation

Material variation

Different materials can be used for the same purpose. The task is constant, but the material varies.

When John's students built vehicles, they got some basic material. The aim was to build a vehicle that could move 1 meter at any direction. The students were allowed to bring material from home and they could also ask John for material they needed, out of the given one.

> John: Are there any more of you that brought things from home? You asked for electricity pipe and you have brought it. Very good.
> Student: Electricity pipe? Or what did you say?
> John: Yes.
> Student: What is that?
> John: Yes, it will be exciting to see what it will be used for. (Lesson 5)

The quotation shows that the supply of material is unlimited, and thereby varies, but the task to build a vehicle is constant.

Example variation

Different examples can illustrate the same phenomenon. The phenomenon is constant but the examples vary.

John introduced the field of work, "Transports", with a question: "What do you think about when you hear the word technology?". He wrote the students' responses on the whiteboard:

What is technology?
Engines
Batteries
Computers
Rubber bands
Lego

One of the students said that everything is technology, and John meant that what he had written on the whiteboard were *examples* of technology. Later that lesson John put household goods on a table. He held up one thing at a time and asked the students if they knew what it was. It was for example a potato peeler, rolling pin and baking tin. He was surprised at the students recognizing all things:

> I thought I had brought things you did not know what they were used for. Obviously you have some of these things at home. And your mum and dad use them and thereby use technology. Don't they? But it is important to remember that everything we do with a specific purpose is about technology. (Lesson 1)

In the quotation[3] John emphasizes that technology is everything you use for a specific purpose. The things written on the whiteboard and the household goods are all together examples of artefacts, which mean technology according to John's definition.

Gradation variation

In this kind of variation it is gradation of a characteristic that varies. The material is constant but the gradation of the characteristic varies.

Gustav's students built a brick wall. They mixed mortar, and Gustav told them how to do. In the quotation below he instructs the whole class.

> Gustav: When you cast you take one part cement and one part water. Sometimes you need sand too, but to this kind of cement we have today, you just mix up with water. Usually you mix one cup of cement and two water.
> Sebastian: Twice as much in other words.
> Gustav: Yes, approximately. But you have to feel your way too, because it mustn't be some slush. It mustn't bee a mess, but rather dry. So it mustn't be too wet, because then it doesn't fix. It is called it does not burn. The cement burns. It becomes fixed. (Lesson 5)

Gustav told the students the proportions between cement and water, but he also told them that the proportions were approximately: "But you have to feel your way too". This means that it required perceptual ability to success with the mixture. In the practical task it was Gustav who judged when the consistency was good enough. The mortar was constant and the gradation of its consistency varied.

[3] All quotations in the paper are my translations from Swedish.

Principle-apply variation

Behind the values in the dimensions of variation in this kind of variation, there is a fundamental idea. To be capable to make a suitable choice or act suitable you need to understand the fundamental idea. The principle is constant, but how you apply it varies.

When John's students built vehicles he gave them some basic material: 4 wooden wheels, 1 balloon, 3 straws and 2 sticks. The aim was to build a vehicle that could move 1 meter at any direction. The students worked in pairs or in groups of three together. There was no instruction how to do, so the students had to figure it out themselves. One solution that was discussed concerning the fuel was to construct a circotherm balloon, as in the quotation below.

Student:	Can I build a circotherm balloon?
John:	It is so hard to get them work.
Student:	Yes, but yet…
John:	I have done it twice, and at both occasions there was a fire. (Lesson 5)

After discussions about circotherm balloon, trap, electric motor and steam engine all student built vehicles that looked like cars with the balloon as fuel. The material they got directed them to use the balloon as fuel and the principle was to use the atmospheric pressure to get the vehicles to move. This was done in two different ways. Six of seven vehicles were driven by a balloon attached to the vehicle. They blew the balloon up and when they let it go the atmospheric pressure drove the vehicle forwards. The seventh vehicle was driven by a balloon that the constructor held in his hand. He blew the balloon up and ran behind the vehicle. The air from the balloon drove the vehicle forwards. The principle was the same in both cases, but the ways of applying the principle varied.

Function variation

When there is a problem that requires a solution, there are different possibilities to handle the situation. Characteristic of this kind of variation is that there is one need to satisfy, but the functions of the solution vary.

The students in Gustav's classroom drew apartment drawings and interior in scale 1:100. The apartments had to be 40 m^2. In the quotation below Gustav gives the student an advice to choose a high bed, which offers space to furnish under it. The quotation is an example of how Gustav directed the students' attention towards functional choices when they chose interior.

Gustav: There is not much space, so you must think about different solutions. You know that you can build things up, a bed for example.
Student: Can I draw six times seven instead?
Gustav: No, you can keep it as it is. Think about a loft. You can have the bed on a loft and thereby save space under it. (Lesson 1)

In the quotation Gustav directs the student's attention towards a functional solution. It is the need to give room to more furniture that lies behind Gustav's suggestion. Another solution that was discussed, for the same need, was using a sofa bed. If you have a sofa bed you do not need a bed and thereby economize on space. Both loft bed and sofa bed serve the purpose to fulfil the need to have somewhere to sleep. The two functions of the solution, accounted for above, vary.

Work in progress – May not be cited

Distribution of the kinds of variation

The kinds of variations described above derive from the empirical data. Tables 4 and 5 are overviews of the distribution of the kinds of variation in each field of work. In the left column all dimensions of variations are named, which were found for every single task (the tasks written in bold). In the rest of the columns the kinds of variation are named. The shaded fields show kinds of variations for every single dimension of variation.

I found 4 kinds of variation in Gustav's teaching: *material variation*,*gradation variation*, *principle-apply variation* and *function variation* (see table 4):

Table 4 Distribution of the kinds of variation in Gustav's teaching in the field of work "Handy at home"

Dimensions of variation	**Kind of variation**				
	Material	Example	Gradation	Principle-apply	Function
Apartment drawing					
Interior					■
Circuit diagram					
Number of wall sockets					■
Sort of wall sockets				■	
Placing of wall sockets					■
Electric cable					
Sort of plug				■	
Build a brick wall					
Consitency of the mortar			■		
Wetness of the bricks			■		
Paper a wall					
Paste consistence			■		
Sort of wallpaper	■				
Ways of join wallpaper				■	
Build a wind power station					
Propellermaterial	■				
Propellermodel				■	
Mount a hook on a wall					
Wallmaterial	■				
Sort of hook				■	

In John's teaching I found 4 kinds of variation: *material variation, example variation,principle-apply variation* and *function variation* (see table 5):

Table 5 Distribution of the kinds of variation in John's teaching in the field of work "Transports"

Dimensions of variation	**Kind of variation**				
	Material	Example	Gradation	Principle-apply	Function
What is technology?					
Artefacts					
Household goods					
The functions of technology					
Fields for everydaytechnology					
Technology history					
Fields for vehicles					
Inventors					
Inventions					
Build a vehicle					
The use of material					
Fuel					
Sort of vehicle					
Ways to construct					
Write a report					
Vehicles					

Discussion

In this chapter I will first discuss the kinds of variation that occurred in both teachers' classrooms, and then discuss each of the teachers' teaching in a more profound way.

Tables 4 and 5 show that there were five kinds of variation available in the two teachers' teaching, and three of them were represented in both classrooms: *material-, principle-apply* - and *function variation*. This means that the technology subject, in these teachers' teaching, was shaped as a question about understanding fundamental ideas in order to make suitable choices or act in a suitable way. It was also a question about satisfying a need, where different solutions were possible. Furthermore it was a matter of using different materials to manage one task. The results are interesting since Gustav and John taught students in different grades and different content. In accordance with Dahlin's (in press) suggestion, the learning content differed but the shape of the subject

as such was to a large extent the same. But there were also differences. Tables 4 and 5 show that there were kinds of variation that appeared just in one teacher's teaching. In Gustav's teaching it was *gradation variation* and in John's teaching it was the *example variation*. I will discuss both teachers' teaching a bit further, and I will start with Gustav.

Gradation variation is about the gradation of the characteristic that varies. In Gustav's classroom there were three dimensions of variation of the gradation kind. It was the consistency of the mortar, the wetness of the bricks and the consistence of the paste. The consistency of the mortar and paste varied while the students mixed it. They could discern a variation of the consistency, and when Gustav told them that it was okay it was possible to compare the consistency of the finished mixture with the earlier one. The students performed the different tasks at one occasion, and had the possibility to compare the consistency of the mortar and paste only during that specific occasion. Gustav discerned variation in the paste between different lessons and between different materials (paste and mortar), so called diachronic simultaneity (Marton, Runesson, & Tsui, 2004). This variation was not explicit for the students, provided that they had not experienced this kind of paste or mortar from outside school. They were not offered this possibility during the lessons.

In Gustav's classroom a lot of the available kinds of variation were implicit. This means that the dimensions of variation did not became illuminated explicitly. Gustav had a broader knowledge of the learning object that he took for granted. One example is when Gustav told the students that how to join wallpapers together depends on the sort of wallpaper, but there was just one sort of wallpaper used in the practical task. There was no possibility for the students to discern the mentioned dissimilarity between different wallpapers. Gustav's statement implies nevertheless that *he* discerns a variation through earlier experiences, so called diachronic simultaneity.

In Gustav's classroom the principle-apply variation was most common, which meant that there was a fundamental idea needed to be understood to be capable to make suitable choices and/or acts. The work proceeded through Gustavs' instructions step by step and he showed the students, practically, how to do. Several times during the theme students asked Gustav what to do and if their result was okay.

In John's classroom there was a great extent of example variation. It was shown through John's focus at artefacts and fields for technology and he told a lot of stories about different inventions and inventors. The shape of the technology subject was to a large extent to learn to see examples of what technology is, with the point of departure that it is artefacts and the use of them. In the practical task, to build a vehicle, the students worked without a detailed

instruction. The task was thereby open for the students' own interpretations and solutions. None of the dimensions of variations became isolated and examined concerning what solutions that benefited the aim of the task (to get the vehicle to move one metre).

Conclusion

The aim of this paper was to present what kinds of variation that were made available in two teachers' classrooms. This study has shown that if comparing the results of two teachers' teaching, there are both differences and similarities. I have shown that some kinds of variation were made available in both classrooms: *material-, principle-apply* - and *function variation*. The learning content differed, but the kinds of variation made available in the teaching was to a large extent the same. The study also showed that the most frequent kind of variation in John's classroom was the example variation, which meant that he showed the students examples of technology as artefacts. In Gustav's classroom the principle-apply variation was most common, which meant that there was a fundamental idea needed to be understood to be capable to make suitable choices and/or acts.

I wrote in the introduction of the paper that it is interesting to discuss how the results affect the shape of the technology subject in Gustavs' and Johns' classrooms. It is of course not possible to generalize the results to the school *subject*, it is more complex than that. Gustav and John are representatives of Swedish technology teachers, and to discuss their teaching makes a good starting point for a wider discussion about the technology subject as such and also about how different school subjects are shaped depending of what the teachers are focusing on during the lessons. So, what I want to discuss at the conference to get help for my continued work back in Sweden is: how do the results affect the shape of the technology subject?

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