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The construction of facts

Preconditions for meaning in teaching energy in Swedish classrooms

Abstract

This article investigates the mechanisms that govern the processes of inclusion and exclusion of knowledges. It draws on three cases from Swedish classrooms about how energy is created as an area of knowledge. We are interested in how knowledge is made valid and legitimate in a school context, and in defining and finding tools to identify structures that govern potential meanings in a certain situation. To do this we develop a theoretical model that explains the preconditions for meaning. The purpose is to understand why certain knowledges are legitimated in the classroom and to explain how this happens.

The analysis is based on participatory observations in classrooms, audio recordings of students engaged in group projects, educational materials and the students' own work.

The apparatuses of the school offer a wide range of possible meanings concerning energy. At the same time there are forces evolved in the school practice that effectively sift out what counts as values from what counts as facts and valid knowledge. These forces create a certain order and certain effects for what counts as truth. The article investigate the nature of the correlations between the different preconditions identified that makes one discourse more likely and "true" than another.

Introduction

> It's the third Monday in October. The pupils I have studied for several weeks are in class with Annika Svensson discussing environment and energy. The classroom is full of Monday vigor – the pupils want to catch up after the weekend. The middle aged teacher Annika tells everyone, with her clearest voice, how environmental degradation is an effect of our way of life, and that up until now we haven't experienced the consequences of how we live our lives. She argues that we're at a crucial crossroads, and that our choice will determine the future of our environment. Annika puts on a slide on the humming overhead projector. The slide has a crossroads and a sign with a number of arrows pointing in different directions. The brown wooden arrows, set on a stick by a country-side crossroads, say 'nuclear power', 'wind power', etc. Annika tells the pupils that there are pros and cons with all the options. –'You should all be able to argue for and against different types of energy sources.' (Field notes, 16-10-2000).

The focus of this article is to understand how objects of knowledge are constructed in a school context, and consequently to investigate the mechanisms that govern the processes of inclusion and exclusion of knowledges (Foucault, 1993, p. 11) drawing on classroom observations of how an area of knowledge is created. The aim is to investigate the creation of an object of knowledge, and consequently also how knowledge is made valid and legitimate in a school context, as well as to define and find tools to identify structures that govern potential meanings and 'system of relations' in a certain situation (Foucault, 1980:194). The first question to ask is how certain meanings are made possible in the classroom. This is a difficult question since meanings seems to appear with some continuity and logic when looking at it in retrospect. Nevertheless there are processes and preconditions in which the meanings are negotiated.

The specific object of knowledge that is treated in this article is *energy*. Energy means different things to different people and there are a number of varying definitions. Some people may associate it with something that happens between actors on a stage, others think of it as 'power' or as something we get when we eat. It has been shown that students' ideas of energy are 'likely to be influenced by a range of factors' (Driver, R. et al. 1997:45-58, see also Solomon J. 1993). For example, energy plays an important role and has an intersectional placement in everyday school practice, and is encountered in traditional subjects such as history, physics and social studies - defining what is important and what is not (Popkewitz & Lindblad, 2000:1). Energy is also constantly relevant in the world outside school, thereby obligating schools to address and discuss energy within its curriculum. This important aspect of energy, taken as an area of knowledge in school, consists of students' everyday experiences with energy, in that their own activities have a direct link both to how energy is addressed in traditional subjects and to current energy discussions in for example the media. Consequently, energy cuts across subject lines in school, and connects strongly to issues outside school, and, thus, there are strong grounds for schools to address the topic.

Method

At the start of the project five different schools where chosen and teachers where interviewed in order to study what happens with energy as an area of knowledge in the classroom. These initial interviews led to an opportunity of following three different energy-related projects where teachers from different disciplines worked together in teams.

This article is based on participant observations of these three projects, audio recordings of students engaged in group work, educational materials, as well as an analysis of the students' own work (Flick, 1998). The three different projects were: (1) two social studies classes that worked using energy as a theme (there were also subject areas such as natural science, language studies and math involved in this theme). (2) A natural science class that also worked with energy as a theme - although the only subjects involved in this class were physics and biology. The abovementioned classes where upper secondary college-preparatory school classes engaged in debate as one type of examination. (3) The study also included two ninth grade classes. As in the case of the social studies classes, their work on energy involved most of the students' subjects. The theme for the ninth grade compulsory school students was 'Man – Energy – Environment'. The age of all the students was between fourteen and sixteen.

Preconditions for meaning

Within discourse theory there are a number of different ways to view the relationship between different conditions for meaning construction (Ibid, Laclau & Mouffe, 2001, Howarth, 2000, Beronius, 1991, Ball, 1990 and Fairclough, 1994). In this article, those conditions are called 'elements'. This does not mean that the elements consist of 'passive' structures, but rather that the structures are *activated* through the creation of meaning and the degree of correlation between, and co-ordination of, the different elements (cf. Laclau & Mouffe, 2001). This 'apparatus' of elements 'is essentially of a strategic nature, which means assuming that it is a matter of a certain manipulation of relations of forces, either developing them in particular direction, blocking them, stabilizing them, utilizing them, etc. […] [b]ut it is also always linked to certain coordinates of knowledge which issue from it but, to an equal degree, condition it.' (Foucault, 1980:196).

When studying energy in school it becomes clear that there are different processes that govern what it is possible to say or write - and what is not (Edwards & Mercer, 1995/1987 and Bergqvist & Säljö, 1994:1). In the work with studying energy as an area of knowledge in school we have identified five necessary conditions for meaning. This section discusses their relations to each other, and to energy as an object of knowledge. These conditions form the theoretical framework that guides this article: (1) *practice*, (2) *discourse*, (3) *subjects disposition,* (4) *interaction* and (5) *materiality*.

First of all, school is a (1) *practice* with a certain history; created and developed under certain circumstances to maintain or change what coming generations should learn (Foucault, 1993, p. 31, Dewey, 1966/1916). This means that there are institutionalized ideas and discourses that are *activated* as soon as you start school (Howarth, 2000, p. 53, Willis, 1991/1977, Edwards & Mercer, 1995/1987). There are, for example, special formal and informal roles, rituals and material settings. This article understands practice as *deposited discourse* (Fairclough, 1994), having different characteristics than discourses: the deposited discourses being the frames that define possible contents. Thus, practice consists of, and offers, the framing rules in which the interaction occurs and that define the subjects involved, their positions, and sanctions possible meanings created. A discourse gives the practice its fundament, potential, stability, and limitations - but a practice also creates its own ways and means.

The second element in the theoretical framework is (2) *discourse*, which is taken to mean how meaning is created, structured and organized (Howarth, 2000). Here 'discourse' is used to understand how the meanings themselves are organized. Discourses objectify various phenomena, or 'objects', via social and historical continuity (Foucault, 2002/1966, p. 264-270) that create certain 'regimes' and certain 'effects' of truth (Foucault, 1990/1976 and Walkerdine, 1984). Thus, discourse refers to *rule-governed meaning formations surrounding a given object* (Foucault, 2002, Mills, 1997, Laclau & Mouffe, 2001, Howarth, 2000, Beronius, 1991, Ball, 1990). Discourses are viewed as concrete meaning structures which have their own *internal logic*, which means that the discourse yields certain criteria and rules for how the objects should be understood.

The third level of the framework engages with different human experiences, ideas, and knowledge. This is called the (3) *subject's disposition.* For an event to become an experience, this unique occurrence has to be interpreted and internalized, and for this experience to be socially shared - it has to be transformed to a set of socio-cultural tools. Even though an experience always is built of (and organized by) socio-cultural defined elements - they are unique (Vygotsky, 1994/1986) - but only as far as the generalized relation between the experiences and the tools for expression allows them (ibid., Wertsch, 1991, p. 19, Wertsch, del Rio & Alvarez, 1995, p. 10-19). Thus, there is always a link between the tools and the experience. The tools make it possible to communicate the experience in a relevant way, which means that experiences are definable - and it is possible to relate to other actor's experiences even though there is always a degree of undefinability that cannot be translated through the tools (Quine, 1992, p. 53-55).

The fourth level, (4) *interaction* is always a part of a practice, and as such it is always subordinate to the particular conditions of the practice. But interaction is also defined by the act of communication - or to use another metaphor - by the 'interactive game' itself (Edwards, 2004, p. 17). 'Interactive games are forms of social interaction, like talk is; but it seems a bit stretched to think of them as 'communication'. They are activities that people engage in, according to a more or less agreed set of rules…' (Ibid.). Some criteria have to be fulfilled to create at least some definability and sense between the actors, and these cannot only be related to the practice in which it appears (Gumperz, 1995, ed.). Interactive games also have their own dynamic and therefore the interaction can be seen as a precondition for meaning. The actors have to *play* the game and accept the rules of interaction. You have to listen, talk, wait for your turn to express yourself, understand what it is all about to a certain degree, and so on. The acts have to be coordinated and the rules make it possible to interact without being interrupted by contingencies.

To understand how knowledge is made valid we also have to take (5) *materiality* into consideration as a precondition for meaning (Latour, 1987 and 1999, Callon, 1986 and Duranti and Goodwin 1995:4). Materiality mediates, or translates, the world in a certain way and therefore materiality must be seen as an important part in the meaning creation process (Wertsch, 1991). Materiality and our tools are intimately interweaved with our preconditions for acting upon the world and our ways of thinking (Latour, 1987 and 1999, Callon, 1986). In one sense materiality is a co-producer of meaning, and can be viewed as a, sometimes unpredictable, condition for meaning (Latour, 1987 and 1999, Callon, 1986).

The elements outlined above influence the construction of meaning in every situation, but how much each element influences differs from case to case. The importance of each element cannot be predetermined since they play totally different roles on the basis of different principles.

In school, several different types of activities have implications for knowledge, for example group work, lectures, laboratory exercise, field trips, and examinations. The different activities impact not only *how* it was possible to work with energy - they also give clear directions regarding *what* energy is. The activities played different roles and activated different elements even though all activities were subordinated the practice. Many of the activities cannot be distinguished or isolated from one another in the classroom as many activities form clusters of co-occurring activities (like searching information, speaking with the teacher, reading instructions, playing with classmates). Several different activities were brought into play when the classes were studying energy and helped define it.

Group work allowed the subject's disposition to influence the construction of energy as an object of knowledge, increasing the relative importance of this element of knowledge construction in relation to the others. More complicated (according to the teachers) concepts and theories, needing explanation and structured review, were handled through the *lectures* where the discursive element was mobilized to control knowledge acquisition. In *laboratory exercises* materiality and discourse became important elements through the actions that were mobilized to construct energy and the methodological and theoretical worldview that was marshaled to interpret the laboratory exercises. In the *field trips*, through the guide's technical verbiage, students were introduced to a specific technical-scientific discourse about energy, backed up with impressive amounts of material elements. The *examination* governed the focus in all the different activities to a high degree - even though the content had to be negotiated more in some of the activities (the group work for instance).

In the three cases studied, different strategies or mechanisms developed which regulated what the students addressed, how they addressed it, and how they dealt with energy as an area of knowledge. The following section examines how the different elements of the outlined theoretical model become activated in different school activities, and thus how certain activities exclude and include certain aspects of energy as an object of knowledge. The focus lies on understanding how knowledge is produced in a school setting in relation to energy. In doing this different modes of defining knowledge is outlined and discussed. The questions that are answered in school practice define what valid, true, and rational knowledge is in relation to energy. This process activates different elements in the outlined theoretical model, and thus different processes of knowledge creation become activated in different modes of working.

Ways of Constructing Knowledge

School offered many different ways to dealing with energy and defining the object energy but there were also strong limits. In the following we will show that there was a demand for objectivity, which meant that a distinction between facts and values was made. The distinction was made explicitly, and there were a lot of different mechanisms and strategies to avoid mixture. This created certain effects on the discourses that were handled. Both teachers and students distinguished between *facts* and *opinions* in a very noticeable and distinct manner. Facts were distinguished from opinions, i.e. from subjectivity. Facts were viewed as something objective and true. Opinions also had their place, but only insofar as they were derived from facts. Individual opinions were not considered to be relevant. Although, opinions could be *neutralized* in various ways, thereby increasing their status as knowledge, even though they were not accorded full status as facts.

The authoritative

In the classroom, it is crucial to know what is regarded as knowledge - and in school as a practice the teacher has a crucial role in governing what knowledge should be about. The different activities, goal documents, the selection of educational material and examination tasks all played a part as instruments or tools for the teacher in directing and defining knowledge. These 'tools' helped the students to *identify* the relevant area of knowledge and to make it *workable* (Bergqvist, 1995). Therefore, some interpretations had to be excluded. This had to do with finding working categories and designing questions that were answerable based on the assumptions and conditions offered by the teachers.

The lecture was a way for the teachers both to show the direction as to what should be considered relevant knowledge, and to give input in a certain area. None of the classes in this study had many lectures, so the few they *did* have were perhaps even more important. One of the methods that were used to organize knowledge in lectures was to emphasize keywords that were used to create a certain understanding about energy. In this process, the students often used abstract concepts like oxygen, dextrose, photosynthesis, or carbon dioxide that they did not use when they for example were asked to more spontaneously formulate ideas and problems about energy in their group work. The following excerpt is from the field notes in the two social studies classes having a lesson with one of the natural science teachers:

T(eacher): 'Energy is more than just *production*! What is life?'

S(tudent): 'Things that grow!'

S: 'Things that breathe!"

T: 'Everything that lives needs energy! How do the plants get their energy?'

S: 'Through *photosynthesis*!'

T: 'What is photosynthesis? What does a plant need to live?'

S: 'Sunlight!'

S: 'Water!'

S: 'Carbon dioxide!' The students raise their hands to answer the teacher's questions. If no one raised their hand the teacher picked someone among the students.

T: 'What do the plants make with this?'

S: '*Oxygen*!'

S: '*Dextrose*!'

T: 'Where do these different things come from, like for example *carbon dioxide*?'

S: 'People!'

S: 'Cars!'

T: 'How about humans?'

S: '*Cellular respiration*!' The teacher writes the keywords on the blackboard and continues to ask questions.

The excerpt shows how keywords are used to create a certain understanding about energy. The concepts above constitute the core of a certain discourse which the teacher thought was important, which had clear connections to the curriculum, and which the teacher thought would be missed by the students if they did not hold a lecture on it. The students were to become familiar with the meanings of the various concepts, and to be able to place them into context. This kind of knowledge did not correlate with the students' own experience of energy, but it was strongly sanctioned by the school as a practice (through the teacher, laboratory exercises and traditional teaching material).

The ninth grade classes had a collage with different cartoons as a vignette and a starting point for their work (Fieldnotes, 20-03-2000). It depicted smoking chimneys, power plants of different kinds, a cross-section of a red cottage, a running man, and a lot of other cartoons that in some way could be associated with the theme 'Man, energy, environment'. The students would associate from the picture and agree on some of the words that later would be written on the blackboard by the teacher. When all the words had been written on the blackboard the teachers and the pupils started to categorize them. In this process it became clear that certain ways of categorizing was not acceptable. For example, one of the pupils wanted the word 'sun' everywhere since, he argued, everything depends on the sun, but the teacher and the other pupils dismissed this idea as 'silly' (ibid). The next step in their work was to formulate (workable) questions. These were to take into account the categories that had been formulated collectively. The day after, and in spite of the fact that the pupils had already formulated questions, the teachers handed out a number of questions that had been prepared by the teacher team. This was founded on a disagreement in the teaching team as to if the pupil's questions were relevant in relation to the course objectives. Several teachers were not prepared to take this risk, and the teachers agreed to a compromise where the teachers formulated questions that were handed out as a complement to the pupil's questions. (Fieldnotes, 14-03-00). All groups chose the teachers' questions over their own for their continued work.

Another important part of learning to distinguish facts was through the task of searching for information. The searching of information, just like the lectures, was also tightly intertwined with an authoritative process of knowledge creation. Trustworthiness and disinterestedness were emphasized when evaluating sources. Also teachers preconceived notions of key information entered into the process through the use of keywords for searching.

In all classes, the teachers had a discussion with the students about the Internet - that it was important to distinguish values from facts, and that the students had to be careful in making this distinction. However, the students were not told how to make this distinction - just that they needed to be careful when browsing the websites of different political parties, and that they needed to exercise judgment when browsing the web for information as there exists a great number of unreliable homepages. When searching on the Internet the students usually used the keywords given by the teachers.

Another source of information was the school libraries. The school libraries were looked upon as reliable sources for information, and the students were recommended to search for information there. The teachers also brought *selected* material from different organizations and energy companies to the classroom for the student to use. Even if the students were expected to find the information they needed on their own, there were clear directions and limits concerning what they should search for and where. Just like the role of a teacher, certain texts had an authoritative place in school, especially when the teacher brings them to the classroom, or when filled with estimates and statistics.

The teachers also had ideas about how the information gathered should be organized. The students where recommended to make summaries of the gathered information - one teacher told the students to organize the information about the energy sources in a table, and another teacher wanted the students to print everything they found on the Internet and staple it together so they then could go back to the same source of information (Social science class, field notes, 11-01-00).

Thus one of the key modes of knowledge construction was the authoritative. This mode linked student's activities with socially sanctioned discourses on energy. Through the use of keywords, classifications of knowledge, valuation of teaching material, and organization of the work a specific discourse on energy was reproduced and sanctioned in the schoolwork. Even though many of the exercises were geared toward the autonomous construction of knowledge the autonomy of the student was fettered to a socially sanctioned discourse through the authoritative mode of knowledge production.

The authoritative way of producing knowledge related strongly to a scientific world of concepts. This was based on two different approaches - one focused on biology, the other on physics. Common to both is the manifestation of 'facts' and their strong links to scientific theories and concepts. Such concepts include 'the energy principle', 'photosynthesis', and 'efficiency'. These concepts were abstract and were mainly brought up by the teacher in their lectures or in traditional school material. The authoritative positions of both the teachers and the traditional school material, sanctioned by the school as a practice, also gave this mode of knowledge production an obvious position as knowledge about energy.

Establishing Neutralized Facts

Another way of establishing facts was to divide the material concerning the various energy sources on the basis of *advantages* and *disadvantages*, as can be expected being the case in debate and in social science debate articles where the students were told to argue for one or two energy sources but this were also the case in other tasks concerning energy sources. Advantages and disadvantages were identified in relation to what is better or worse particularly from an environmental standpoint but also in relation to for example efficiency, risk and ideas of more or less advanced technology.

Lina: Do we have to know all fossil fuels, or is it enough if we know what we're going to talk about in the debate?

L Annika: I think you should!

Peter: But, when we're writing the exam or essay in the assembly room?

L Annika: Yes, you should master all energy sources then.

Peter: So, we're supposed to know all energy sources by heart?

L Annika: Yes, you're supposed to know the pros and cons of different energy sources, and you will on Monday as well! You have studied this for two weeks now.

Peter: Yes, but I don't remember all pros and cons of all the energy sources. (Social science class, 26-01-00).

A number of environmental, economic, or technological criteria were available for evaluating the various sources in relation to one another. 'Energy source selections' entailed that the energy sources were weighed against each other, and the objective is to choose the 'best' source. In order to pick the best source, a number of criteria were used on the basis of which sources could be compared. These criteria were *isolated* both from one another and from a broader context. In this way each individual 'variable' could be compared with the same variable for another source.

From an environmental point of view wind power is very good. For example a 200kW wind power station produces 500 000 kWh each year without emissions. The same amount electricity produced in a regular coal power plant would among other things give the following emissions: 4 tons of sulfur dioxide, 500 tons of carbon dioxide, 25 ton slag and ash'. (Piece of work done by a ninth grade group).

For example, the single most important criterion for the students was the environmental impact of the energy source. Carbon dioxide was considered to be harmful to the environment, and thus it was advantageous for an energy source to be associated with lower carbon dioxide emissions. The isolation of different variables enabled the students to compare for example carbon dioxide emissions from nuclear power plants with carbon dioxide emissions from oil (Natural science group, 20-11-2000).

One of the important processes in knowledge construction was to neutralize the fact and isolate it as a variable that could be pitted against other variables. Thus, the complex web of interrelated advantages and disadvantages was reduced to a tournament that was won by trial of strength.

Quantification as Truth Maker

Figures and quantified also data had a high status as valid and objective knowledge.

> **Ada**: That's great. Mine is great… You're just asking for numbers and years all the time.
>
> **Iris**: But, it should…
>
> **Ada**: But, yours sounds better than mine.
>
> **Hjördis**: Yeeeeeeeees I think
>
> **Iris**: But, then it's good right?
>
> **Ada**: Yes, yees… It's become thicker. (Group work ninth grade class, 23-03-00).

Knowledge should preferably be measurable and precise. On this basis, quantified descriptions of the world were accorded high status, which thus imposed restrictions on what could validly be expressed with regard to energy issues. Even in the group work arguments based on quantified data were very common. The quantification gave the authority of precision and was hard to question. Figures and numbers are also easy to compare according to for example emissions or the amount of produced electricity. With the figures these comparisons could be done in an 'objective' way. There was strong support for this way of describing the world in brochures and on the Internet, and the figures where reproduced by the students:

> Heat and power waste incineration plant which is located in [Walköping] processes about 230 0000 metric tons of waste from many municipalities in central-Sweden, it is waste from over half a million people. It corresponds to about 70 000 tons of oil/year. The incineration produces about 50 000 tons of ashes every year. Magnetic scrap metal is removed and there are about 4000 tons of iron recycled every year. (Piece of work done by a ninth grade group).

Through the figures, proportions were created and different energy sources could be valued in a neutralized and legitimate way. Sometimes the students even expressed the idea that the figures themselves were something good and positive, and that what distinguished good work from bad work was the amount of figures and the size of the work (ninth grade group, 23-03-

2000). The trust put in numbers in the school setting can be compared to Theodore Porter's (1995) argument that numbers are a way of making knowledge objective, and independent of the people that produce them, and thus is a political tool that is used to gain trust outside small communities.

Establishing Scientific Facts

Other connections were made to scientific practice and scientific modes of expression. The laboratory exercises bore the stamp of a scientific methodological and theoretical worldview and it presented nature as being measurable and controllable. The laboratory exercises meant that the students had to think about energy in terms of formulas, principles and transformations.

> Read the thermometer and insert it into the cork. Slowly twist it back and forth and read it again. Which energy transformations occur? (Field notes, social science class, 24-01-00).

With different apparatus to create an experimental situation, or to measure certain processes, the materiality became more obvious. The water boiled after a certain time with the plate the students used, different metals reacted differently when inserted into a lemon, and the instrument did not work because the school instrument was out of date. The laboratory exercises were very standardized. There were carefully defined steps with almost no room for interpretations, and the students could compare their results with a key with exact and measurable answers.

In the different labs the student had to interact with the materiality in a consciously more active and direct way to sort out the tasks than in other activities. They had to use electricity and radiation gauges, speakers, bicycle generators, solar cells, small toy cars, batteries, watches, lamps, and different chemical compounds. (Field notes, natural science group, 23-10-00). The materiality delimited potential meanings by getting hot, by being heavy, sour or just by taking time to change position or form. At the same time, the students had detailed instructions for the procedures - what to do, in what order, what to look at, and which formula to use (ibid.). Despite the fact that the expressions of materiality can be interpreted in different ways, the expressions themselves and their correspondence with other elements cannot be neglected. In this certain context, materiality has a very strong role to play, which makes some interpretations impossible (due to the restrictions imposed by materiality itself). The interaction focused on how to do the tasks, how to measure, and on the measure results. The students as persons seemed rather interchangeable.

Laboratory exercises contributed to making energy as an area of knowledge into a scientific discipline, and described nature as measurable and controllable. To solve the laboratory tasks they had to be in a special place, use certain machines to be able to measure different kinds of energy conversions, and they had to report their results separately. This would indicate that these discourses were not something that the students themselves automatically associated with energy, but rather were imposed 'from the outside'.

Much of the same processes that were used to establish neutralized facts in relation to disadvantages and advantages were poignant in the laboratory exercises. The controlled nature of the experiments, the measuring apparatuses, and the links to formulas, principles, and transformations all reproduced a scientific culture. The apparatuses became the focus for the pupils interactions and the pupils own experiences were accorded substantially lower influence on the knowledge. In the school laboratory energy was constructed as measurable and controllable, adding to a scientific understanding of energy. This world-view was supported by the authoritative and the neutralized modes of constructing knowledge.

Establishing Realistic Facts

Another way of viewing energy-related problem sets arose from the distinction between a *threat* and a *risk*. The distinction was made in the interactions among the student in the group work and not in other activities. Risks represented a more objectivistic viewpoint that fit in smoothly with a neutralized way of producing knowledge. Countering the risk discourse's objectification of potential dangers was a more subjectivist approach to threats. This approach confronted the risk discourse's tendency to reduce important values (e.g. the value of a human life) to technically and economically measurable and negotiable dimensions.

The discourses that were more critical of civilization could not resort to any of the neutralizing practices, since their demands would entail comprehensive and uncontrollable changes in society. They could thus not be asserted in the face of the technical or economic arguments of the (natural) scientific discourse, or against their bar graphs, numbers, lifecycle analyses, or faith in man's ability to solve problems. The civilization-critical discourses instead raised issues that questioned and problematized conventional notions.

Tove: But, nuclear power plants - do you know how dangerous they are, or what? It's bloody…

Jonas: In Sweden nuclear power isn't a problem but in Russia, on the other hand, maybe they blow up now and then.

Tove: Yeah, exactly!

Jonas: But in Sweden…

Tove: Aren't they older?

*Jonas***:** In Sweden they're very safe!

*Hanna***:** But still!

*Tove***:** But still, they're dangerous – really dangerous!

*Jonas***:** Noooo…

*Tove***:** Yeah, because if something happens… a small thing… it can become a bloody big deal – and one risk with that is… what is it called…these dangerous things…

Jonas: Let's pretend Oskarshamn blows!

Hanna: Yeah!

Jonas: Life goes… life… Sweden… we can expect to…

Hanna: 'Life goes on!' [laughing]

Jonas: Life goes on, yeah!

Hanna: For some yes, but not for others!

Tove: But look, about this thing in Russia, you know, what is it called… God - what is it called?

Jonas: Tjernobyl, is that what you're after?

Tove: No, these dangerous things that are in there spread and we, as humans, can't survive if that happens.

Jonas: Yes we can!

Tove: No because they make us sick inside and we die! Yeah, but it… OK then you accept it but we don't…

Jonas: Yeah… yeah, honestly speaking I accept it because we humans die all the time! (Ninth grade group, 21-03-2000).

The excerpt illustrates how two different discourses are confronted with one another. For Jonas it is a question of calculations and probability - whereas for Tove and Hanna it is a question of a threat which could result in people dying. Hanna and Tove are not interested in discussing the fact that other energy sources might be worse. For them it is a moral and unquestionable standpoint. When the pressure gets too much for Jonas he turns to a boy in another group to get some help with his argument and now it becomes clear even for Tove that they speak two totally different languages.

Jonas: Jerry! Can you give an estimation of how many people that would die if a big…or a dangerous nuclear disaster were to occur in Oskarshamn… or a *big* nuclear disaster?

Tove: It's so different… You speak such different languages in the group… Like: 'Could you give me an estimate?' Then I say can you suggest a percentage or something…

Jerry: Firstly, the risk of a nuclear disaster in Oskarshamn is small – extremely small! (Ninth grade group, 21-03-2000).

Claims like Tove's and Hanna's, however, could be brushed aside because they provided no alternative answer to the question of how things should be. Their claims were not sanctioned as valid knowledge within the school practice and Tove and Hanna could not find support for their claims other than in their own feelings.

There was also a strong idea about Swedish technology – 'their own' – as more advanced, safe and, in an essential way, better than other technology. Critique of the energy system was only legitimate to a certain limit, and this limit was drawn in relation to what were considered realistic solutions to the problems at hand. In one of the social studies classes groups they discussed what to do when the oil has run dry, and they spoke about scientist estimations of when this will occur. One student suggested that we have to change to public transport solutions as soon as possible, but this suggestion was seen as an unrealistic alternative, and the students started to discuss different kinds of fuels instead. Science and technology can solve these problems - it is just a matter of when. Changes had to be grounded on new technology and scientific knowledge – the project of modernity must not be risked.

These discourses deviated from the customary ways of approaching energy. They also called into question society and its ways of handling problems on a more fundamental level. Common to these discourses was that the teachers did not sanction them. They tended rather to make the dominant approaches to dealing with energy as an area of knowledge even more apparent. These discourses did not offer any acceptable solution to how to solve energy problems. Their claims could be brushed aside because they provided no alternative answer to the question of how things should be, and they were not sanctioned as valid knowledge within the school practice. Neither did those discourses correlate with other elements activated in school than with some students own feelings (subject disposition) which, per definition, did not qualify as facts.

Discourses as facts

Discourses find their special niches where the elements, together, create a certain pattern and where other discourses suddenly become impossible and therefore will be excluded. The hegemony created between the different discourses, and therefore also what the area of knowledge was about, depended on the *mixture* and activation of the different elements in a specific activity. Different discourses also suited the demands on knowledge of the school practice differently. The success of the discourses depended on the discourses ability to adjust to these demands.

The 'truth'- or the hegemony between discourses - created in the classroom depends on how successful a discourse is in its *correlation* with other elements. The discourses are created by certain meaning-relations through which the objects are determined. The force seems to be most clear and effective where the elements meet, in the process of correlation between the elements (Hook, 2001:11, pp. 529-530). It does not matter how good the argumentation is if it does not fit the elements at hand.

In the laboratory exercise there was not much room for the student's own experience (subject's disposition). The activity was strictly formalized and the answers precise. In the group work, the subject's disposition became very important to carry on the work, and the content became something totally different than in the laboratory exercise for example. In the group work, the student had to figure out what they were expected to do and focus while the other activities had a more given content with readymade answers. Still, the students had to adapt what they brought up, and their ways of formulating and presenting their own ideas to match the demands on knowledge in school.

The most dominant discourse, however, was the *supply discourse*. This discourse was manifested in the teachers' goal documents, in the construction of examinations, during field trips, and in most of the educational materials used by the students. The supply discourse found expression in the idea that energy-related problems had to do mainly with *energy source choices*. This approach to energy as an area of knowledge was highly consistent with the requirements and ideals of the scholastic practice with respect to what constitutes legitimate knowledge. It was highly represented in the traditional school material, brochures, and on the Internet. The supply discourse was also reflected in the way in which tasks were presented, how they were tested, and last but not least, students had their own experience from outside school (media, at home) where the supply discourse had a very strong position (Anshelm, 2000 and Gyberg, 2003). The supply discourse had strong correlations in almost all the different activities. The field trips to different power plants also gave the supply discourse a concrete material confirmation.

Sometimes discourses seem to borrow attributes from one another to fit the composition of elements even though they might be meaningless in their new context. The supply discourse delivered a lot of figures (e.g. tonnes of carbon dioxide) without defining the limits for the system at hand (e.g. nuclear power). Even if the figures actually did not say anything the way they were presented, they counted as valid knowledge in school because the figures are considered exact and therefore taken as facts.

Conclusions

The apparatuses of the school offer a wide range of possible meanings concerning energy. At the same time there are forces evolved in the school practice that effectively sift out what counts as values from what counts as facts and valid knowledge. These forces create a certain order and certain effects for what counts as truth.

The understanding of energy as an object of knowledge was influenced by a multitude of factors: materiality like laborations helped to make scientific and objective energy; the definition of authoritative sources of information helped the students distinguish between knowledge and propaganda; task definitions shaped discussions and valid concerns. Objective neutralized knowledge was constructed by trials of strength and through bringing the trust in numbers to bear on the problem. Energy was also made scientific through the use of certain key words, precise and shaping definitions of what energy was, and the measurability of key factors in relation to the energy sources. We argue that the facts became transformed into what has been termed immutable mobiles (Latour, 1987): Knowledge was stripped down, isolated, and black-boxed in order for it to survive in the school setting.

These elements and processes served to exclude other concerns with energy, like fear of nuclear catastrophe, or the energy conservation as valid means of approaching the object of study. Energy as an object of knowledge was produced in a particular manner that equated concerns with energy with objectivity, a scientific worldview, and a focus on the supply of energy.

In light of the considerable amount of uncertainty in relation to for example scientific energy and climate modeling it is important to understand that the current modes of teaching often fail to convey the broad span of unknowabilities in energy science (Jäger, 1998; Hansson, 2008). In school and elsewhere the illusion of objectivity imparted by numbers and formulas black box this uncertainty, and hide the scientific processes that could lead to critical reassessment of energy knowledge in the school setting.

The processes that led to this mode of knowledge production are crucial to understand in an educational setting that aims to foster critical thinking as a crucial element of this is to think outside of established norms, and make judgments based on other values than those that are dominant. In creating an educational setting that fosters these traits it is of utmost importance to foster a certain way of organizing the school setting that allows students to move outside established patterns of producing and understanding knowledge.

In this endeavor the understanding the scientific, authoritative, and quantitative modes of knowledge production in an educational setting makes it possible to foster alternative ways of student interaction and problematization. To make a critical stance possible there must exist ways of moving outside the established norms.

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Construction of facts

By Per Gyberg & Francis Lee

Dear Prof. Lederman

We agree with the reviewers' comments on our text "The construction of facts" that the main problem is that it "does not present the data in a compelling way" (reviewer 2), that we don't present "good data sets upon which to make analyses and draw conclusions" (reviewer 2) and that we have to provide more detailed data, and "thoroughly and tightly analyze them" (reviewer 1).

We have tried to meet these comments by:

1. Using more examples from data and thereby also give a better description of setting as well as making our arguments stronger in relation to data(marked in yellow)
2. Description of setting (marked in red)
3. Making stronger arguments connected to theoretical assumptions (marked in green)
4. More clearly connect our assumptions to data (marked in blue)

We hope that these actions meet the reviewers' comments.

Best regards

Per Gyberg and Francis Lee