SCIENTIFIC TRUSTWORTHINESS – THE CONSIDERATIONS AND PERCEPTIONS OF STUDENTS

Mats Lundström & Anders Jakobsson

SAMMANFATTNING

I den här artikeln beskrivs och diskuteras en empirisk studie där gymnasieelever diskuterar olika förklaringsmodeller kring ämnesområdet kropp och hälsa. Syftet har varit att utvärdera och analysera elevernas användning av begreppen tillförlitlighet och trovärdighet i förhållande till såväl vetenskapliga som icke-vetenskapliga förklaringsmodeller. Vi har analyserat elevernas användning av olika epistemologiska resurser i argumentativa situationer. Analysen ledde fram till att eleverna använde fyra olika typer av epistemologiska resurser; relativistiska, normativa, auktoritativa och vetenskapliga. Resultaten visar att samma elev kan använda olika epistemologiska resurser vid olika tillfällen. Vi anser att vårt teoretiska ramverk som utgår från epistemologiska resurser kan bidra till att förstå hur individer använder olika förklaringsmodeller i olika sammanhang.

Nyckelord: Epistemologiska resurser, pseudovetenskap, argumentation

INTRODUCTION

The concept of nature of science (NOS) has been in focus in a large number of research studies in recent decades and the significance of both students' and the broader public's understanding of this area has been highlighted by several scholars in the field. For example, Lederman (1992, 2007) asserts that students' perceptions of NOS, above all relate back to their understanding of the epistemology of science; science as a way of knowing, or the values and beliefs that are inherent to scientific knowledge and its development. According to him, the concept is also related to issues of ontology; i.e. how individuals understand which concepts and categories they need to use in order to give coherent and consistent descriptions or explanations of the world. Sadler, Chambers and Zeidler (2004) argue that students' understanding of the concept may become explicit when they are involved in discussions about issues related to scientific trustworthiness and reliability in contemporary science. In their study, upper secondary students in the US were requested to evaluate the scientific trustworthiness of popular scientific articles. The study revealed that the students had a strong tendency to overestimate the trustworthiness of articles that supported their own original idea. Kolstø (2001) found that students in Norway expressed strong hesitation in evaluating what kind of sources to trust when they examined statements related to the risks of power transmission lines.

One way of understanding why issues related to NOS and scientific trustworthiness seems to cause such problems for students may be to use Cobern's (2000) framework. He asserts that an individuals' different interpretation of the world and world view may be explained by the epistemological macrostructure, which constitutes the fundamental organisation of mind and influences how we view, act and argue in and about the world. However, Hammer and Elby (2003), and Hofer (2001, 2004a) take another philosophical perspective when arguing that an individual's understanding of scientific trustworthiness is related to their personal epistemology and to what kind of epistemological resources the individual is able to use. According to them, personal epistemology is dependent on what encounters and experiences the individual has had, and the kind of epistemological resources the person actually uses is strongly related to the specific context or situation. From this perspective the different epistemological resources used by an individual are not seen as stable, mental entities but rather different argumentative resources whose use is dependent on the situation or context. Thereby, this perspective differs from studies that connect epistemological beliefs with cognitive structures (i.e. Wu & Tsai, 2011).

In this study we intend to use framework of Hammer and Elby (2003), Hofer (2004a), Hofer and Pintrich (1997) in order to explore upper secondary students' considerations and perceptions of scientific trustworthiness through analysing what epistemological resources they use when discussing issues related to the human body and health. The student assignment is to evaluate the scientific trustworthiness in texts and articles that are related to scientific, as well as non-scientific explanations.

MATS LUNDSTRÖM
fil. dr lektor i naturvetenskapernas didaktik,
Malmö högskola
Lärande och samhälle, 205 06 Malmö
E-post: mats.lundstrom@mah.se

ANDERS JAKOBSSON
Professor med inriktning mot de naturvetenskapliga ämnenas didaktik, Malmö Högskola
Lärande och samhälle, 205 06 Malmö
E-post: anders.jakobsson@mah.se

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THE ABILITY OF STUDENTS TO EVALUATE SCIENTIFIC INFORMATION

Erduran, Simon and Osborne (2004) argue that one way to develop students' understanding of issues related to the nature of science is to focus on the students' use of arguments when they are involved in discussions about science. The authors suggest, for example, a focus on educational situations where students are requested to work with so-called socio-scientific issues. These tasks tend to be less well structured, more value-laden and open-ended than standard learning tasks that are framed within accepted disciplinary discourses. In these situations, learning science seems not only to be related to learning scientific concepts, problem solving skills and process learning, but also to students' appropriation of the practice of argumentation in scientific communities. Bricker and Bell (2008) also focus on science learning in situations where explanations and models of scientific phenomena are jointly constructed through social discourse in which the explanations and models are questioned, evaluated and revised. Several studies indicate that this way of organising science lessons creates opportunities of developing the students' understanding of scientific trustworthiness and reliability. For example, Ratcliffe and Grace (2003) show in a study that students improved their understanding of these issues and their reasoning skills related to NOS when working with socio-scientific issues, especially if the teacher facilitated the discussions with well-structured questions about the content. Other researchers (e.g. Erduran et al., 2004) assert that this way of organising science education develops the students' abilities when it comes to seeing and exploring new perspectives. In their study, the students increased their ability to use counter-argument and rebuttals to higher degree than other students.

However, a lot of other studies indicate that the development of students' understanding of issues related to scientific trustworthiness and reliability may be problematic. For example, in a study by Sadler et al. (2004), upper secondary students were requested to evaluate the scientific value of popular scientific articles. The results revealed that approximately 40 % of the students had a tendency to overestimate the scientific value of articles that supported their own original idea. Kolstø et al. (2006) investigated the ability of 89 science student teachers to assess the trustworthiness and reliability of different scientific claims in popular science articles during group work. The students' answers and statements were analysed and categorised from 13 different criteria, such as the students' abilities when it comes to evaluating the empirical and theoretical adequacy, the completeness of information and the social aspects in the articles. The result indicates that the students above all focused on the consistency or validity of the argumentation in the articles, and that they emphasised the importance that the conclusions in the articles did not go beyond the referred evidence. When it comes to the social aspects, the students questioned the possible influence of the underlying institutional interest and the competence of the authors or experts. According to the conclusion of the study, the quality of the students' critical examination clearly indicates that these issues need to be emphasised in science teacher education

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in the future. Korpan, Bisanz, Bisanz and Henderson (1997) also point to the fact that science students in general usually request more information about how the empirical part of the research process is conducted when they assess the value of short news items with scientific content. Additionally, the students often ask for descriptions of how the researchers were able to draw conclusions from their research. Very few of the students raised questions about closely related research or if other research studies have come to the same conclusion.

In another study Kolstø (2001) found that 16-year-old students in Norway expressed hesitation when it came to evaluating what kind of information to trust and what sources to believe when they examined statements related to the risks of power transmission lines. In the study Kolstø used as a basis for interviews a news item about power transmission lines and their significance in relation to leukaemia. The analysis identified four different resolution strategies that were used to different extents by the students when they assessed the information in the article. The resolution strategies were *acceptance of knowledge claims, acceptance of authority, evaluation of statements and evaluation of authorities.* Most of the students only used one of the strategies but some of them could use more than one in order to come to a conclusion. However, according to the author, the students to some extent were able to draw conclusions regarding the trustworthiness of the knowledge claims, the reliability of the information and arguments used in the articles.

THE STUDENTS' WORLDVIEW AND PERSONAL SCIENTIFIC EPISTEMOLOGY OF STUDENTS

Cobern (2000) argues that the ability to understand issues about the nature of science and to assess and evaluate scientific trustworthiness and reliability in contemporary science is, above all, related to the individual's worldview. According to him, the individual's worldview is mainly established in early years and is difficult but not impossible to change during a person's life. Formal schooling may build up cognitive frameworks that can influence the world view and the epistemological macrostructure. Hofer and Pintrich (1997) and Hofer (2001; 2004a) take a different philosophical perspective when describing the individual's beliefs and knowledge about the world in terms of *personal epistemologies*. They argue that all individuals successively and constantly develop their personal epistemology during life and that this also constitutes how and in what ways individuals evaluate information and draw conclusions about phenomena in the world. Additionally, they refer to personal epistemology as the theories and thoughts about knowledge and knowing that the individual develops during encounters in the social and cultural world. This implies that individuals develop different *epistemological resources* (Hammer & Elby, 2003; Hofer, 2004a; Louca, Elby, Hammer & Kagey, 2004) due to what they encounter and experience, and that these resources may be utilised in different contexts or discourses. According to Hammer and Elby (2003) and Hofer (2004a) the idea the individual seems to use of different epistemological resources on different occasions may explain the phenomenon that people are able to express different world views or understandings, depending on what situations or contexts

they are involved in. From this perspective, the different epistemological resources used by an individual are not seen as stable, mental entities but rather as different argumentative resources whose use is dependent on the situation or context.

In relation to research on the world view of individuals, Hofer (2004a) argues that carefully conducted explorations of the personal epistemology, used in action may create a framework for describing and analysing an individual's personal theory of knowledge and a tool to analyse which authorities the students believe and why. Hofer (2001), and Rizk, Jaber, Halwany and Boujaoude (2012) describe various strands in personal epistemology such as knowledge construction, sources of knowledge, evaluation of knowledge and progression and development of knowledge. Additionally, Hammer and Elby (2003) and Hofer (2004a) refer to resources as context-dependent and situated, which imply different kinds of analyses than used in studies where knowledge is viewed as stable and constant in all contexts. However, Hofer (2004b) calls for more observational studies about individuals' personal epistemology in everyday and educational settings; studies that focus on the individuals' view of the nature of science and students understanding of issues related to reliability, trustworthiness and justification of knowing.

One study that partly explores these perspectives is Hansson's (2007) study about upper secondary students' understanding of the Big Bang theory. According to the author, the results indicate that the students' worldview makes it possible for them to present and understand scientific explanations without making them their own in other contexts. The students were able to describe thoroughly and use explanations about the theory during physics lessons despite the fact that their own ideas or beliefs actually were quite different. The study also reveals that most of the students were not familiar with some of the fundamental presuppositions or ideas that relate to a scientific worldview about the universe, despite the fact that they have chosen to study the natural science programme in upper secondary school. In this way, the study clearly indicates that the personal epistemology used by students is related to the situation in which individuals evaluate and assess new information and when they form their ideas about what can be counted as scientifically trustworthy. Sinatra, Southerland, McConaughy and Demastes (2003) also investigated students' understanding of the reliability and trustworthiness when related to issues of different scientific content. They found that students to a relatively high extent seem to accept the scientific explanation of human evolution but expressed hesitation or even scepticism in relation to evolution in other species.

In conclusion, the authors elaborate on possible explanations in a discussion about the relation between the students' ability to display scientific knowledge on the one hand and their willingness to accept the same knowledge as their own on the other. In another study, Lundström and Jakobsson (2009) found no obvious correlation between students' knowledge about the human body and health and their tendency to agree or disagree with non-scientific explanations and statements. The results indicate that the students' level of knowledge of and about the function of the human body did not automatically seem be related to their dissociation

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with non-scientific or even pseudo-scientific statements about the human body and health. Shermer (2003) comes to a similar conclusion and argues that our beliefs or ideas about the world are often not immediately related to empirical evidence and logical reasoning. Instead it seems that social and cultural influences such as family and peer pressure, experiences and life impressions have a strong impact when we make choices of what we believe in.

All these studies clearly demonstrate the complexity of the relationship between the individuals' displayed knowledge and their acceptance of that knowledge as a part of their own world view. However, we argue that the difficulties of interpreting and fully understanding these issues should not prevent the research community from taking further steps in order to increase its understanding of them. A number of scholars, such as Sadler et al. (2004) and Hofer (2004a), suggest advancing research on this matter by studying students' understanding of the nature of science; to focus on their understanding of reliability and trustworthiness and to interpret their use of epistemological resources in different contexts and in argumentative situations.

PURPOSE AND RESEARCH QUESTIONS

As mentioned, several research studies in recent decades have explored the understanding of the nature of science in students, as well as other individuals: scientific trustworthiness and issues related to the personal epistemology of individuals. Hofer (2004a, 2004b), and Hammer and Elby (2003) refer to personal epistemology as different epistemological resources that individuals are able to use, dependent on what encounters they have previously experienced and that these resources can be utilised in different contexts or discourses.

In this study, we use this framework in order to explore what kind of epistemological resources upper secondary students actually use when they discuss issues related to the human body and health. The student assignment is to assess and evaluate the scientific trustworthiness in texts and articles that are related to scientific, as well as non-scientific explanations. The research question in this study is:

In what ways may students' considerations and perceptions of scientific trustworthiness be expressed through their use of different epistemological resources?

METHODOLOGICAL CONSIDERATIONS AND ANALYSIS

This study is a part of a larger research project where the understanding of upper secondary students' ideas about the nature of science and the relationship between scientific and non-scientific explanations are investigated. Our earlier study (Lundström & Jakobsson, 2009) explored nearly 300 students' ideas of issues related to the human body and health and the relationship between the students' knowledge and their perceptions of scientific trustworthiness. The design of this study made it possible to describe what kind of statements the students believed were scientific trustworthy or not. However, it did not actually succeed in explaining

the students' underlying argumentation or their use of different epistemological resources. In order to capture students' reasoning and their use of epistemological resources requires carefully conducted observations during active, argumentative problem-solving situations in an everyday classroom discourse (e.g. Jakobsson, Mäkitalo & Säljö, 2009). This implies that the focus in this study have to be on the students' use of epistemological resources in action, when they make sense of school assignments and on their perceptions of trustworthiness in relation to these assignments.

In order to study these issues two different assignments (see appendix 1) were intentionally constructed by the researchers. The first assignment (Case A) consists of a person's description of her allergy. She wants to know what causes her problem and two alternative explanation models are presented. The first is a text that relates allergic reactions to the immune system and anti-histamines, and a description of the medicine was given to the students. The second alternative uses a non-scientific explanation which assumes that her allergy is the result of unresolved conflicts and a suggestion that a 'cure pendulum' may ease the symptom. (Some people and pseudoscientific organisations claim that the pendulum responds to 'electromagnetic energy that radiates from everything on Earth' and that it can cure illnesses.) A pendulum and a description of how to use it were enclosed with this assignment. In the second assignment (Case B), the students were requested to discuss different factors that may have an impact on an individual's state of health. The first explanation model consisted of a medical text that suggests that human health may be understood from of a combination of the individual's lifestyle, environment and genes. The second explanation uses a non-scientific model including astrology and a predestined view of human health. The aim of constructing these two assignments was to explore what kind of epistemological resources the students use when they are involved in discussions about trustworthiness related to different explanation models. The two cases were not traditional socio-scientific issues in which an important question for the society was investigated from scientific perspective. However, the two cases included different perspective on science and were less well structured, more value-laden and open-ended than standard-learning tasks that are framed within accepted disciplinary discourses, as proposed by Erduran et al. (2004).

31 students (aged 16-17) in their first year of the science programme in upper secondary school in Sweden were chosen to participate in the study. The selection of science students can be regarded as typical *case sampling* (Patton, 2002) because all of the students, to some extent, belong to a similar culture in that they are enrolled in the science programme. The science teacher in the participating class had answered a call for voluntary science programme classes. All students, except four, agreed to be involved in the study. The research project followed the law on ethical considerations applying research that involves humans and met the demands with respect to information, consent, confidentiality and use in the research process (CODEX, 2010). The students themselves chose their pseudonyms used in the excerpts. The students worked with the assignments (Case A and B) in mixed and single gender groups, with 3-5 students in each group in an ordinary school setting. Each group was videotaped during all of their discussions and excerpts of these discussions constitute the total empirical material in the study. The regular classroom teacher moved between the groups and made comments or asked questions in order to facilitate the discussions, which aimed to create an authentic everyday classroom situation (see Goldman-Segall, 1998). This setting was supposed to facilitate the students' use of scientific argumentation.

However, according to Mork (2005), the main focus of research on argumentation on controversial issues in science education has usually been the process of argumentation rather than the factual content of the arguments used in the discussion. The dominating analytic tool used has been Toulmin's (2003) argument pattern (TAP). This model assumes an analysis of the different types of utterances, such as the declarations or the rebuttals people use in argumentation in order to underpin their statements. Several researchers like Erduran, Simon, and Osborne (2004) and Mork (2005) argue that the problem of using the TAP-model is that the model does not include an analysis of the content of the argument. Additionally, Driver, Newton and Osborne (2000) argue that the semantic and situational contexts are important when analysing arguments and that Toulmin's TAP does not take this into account. We have considered these arguments and the criticism carefully, especially as the focus of our research concerns, above all, the content of the students' argumentation. From this starting point, the analysis of the students´ arguments and use of epistemological resources followed a two-phase model.

In the first phase, the thematic patterns (Lemke, 1990) of the discussions were identified. Lemke describes thematic patterns as a pattern of connections between the meanings of words. In this way the pattern may be 'semantic relationship that describes the thematic content, the science content, of a particular area' (Lemke 1990, p.12). He argues that there is always more than one thematic pattern woven into discussion, where sometimes alternative patterns may be those of common sense or everyday language. The purpose with this phase has been to find the general themes or patterns that most of the students frequently expressed. When different arguments were analysed, utterances and statements related to judgements of the scientific trustworthiness in the explanation model became particular thematic patterns to focus on in this first phase.

The next phase of the analysis has been to identify, transcribe and categorise what kind of epistemological resources the students actually used during the discussions about trustworthiness. This phase of the analysis focused on in what ways individuals evaluated and concluded on the available information. In other words, the students' use of different argumentative resources guided the analysis (Hammer & Elby, 2003; Hofer & Pintrich, 1997; Hofer, 2004a). In this phase the transcripts were read several times, looking for the typical or the unique, and for similarities and differences. The categories are in this way constructed from the material and not predefined. After this first categorisation, the authors tested the validity by rearranging the different statements in new groups in order to find new categories until the stage where the two interpreters reached consensus. Additionally, we

neither claim that the described categories constitute the only ones possible, but acknowledge that continuing studies probably will complement the image further.

RESULTS

As mentioned, the main task in this study has been to explore in what ways students' considerations and perceptions of scientific trustworthiness may be understood through the analysis of their use of different epistemological resources when discussing trustworthiness in relation to scientific as well as non-scientific explanation models. In the first example from the empirical material (Excerpt 1), four students, two girls (Gucci and Sonja) and two boys (Grebe and Gaban) are involved in a discussion about what kind of factors that may affect human health in general. The assignment (Case B) the students are engaged in is formulated as a dilemma where two different explanation models about what may influence health are presented. The students are requested to discuss and consider the scientific trustworthiness of the two explanation models and come to a joint decision. In the introductory part of the dialogue, Sonja expresses the idea that it is actually not possible to be sure if the movements of the planets may affect humans in some way or not. This statement seems to stimulate the discussion and to explicate what kind of epistemological resources the students use in this specific situation. The first excerpt constitutes an example of this discussion.

Excerpt 1

1 Gucci:	What do you think?
2 Sonja:	I think that the movements of the planets affect us, ... yes.
3 Grebe:	In what way?
4 Sonja	I don't know, but everything affects us in some way...and the earth rotates
5	[Pause 2.0]
6 Sonja:	...you don't really know if it is true. Nobody knows. But it sounds a little... [shakes her hands] it sounds like a movie, that the stars...
7 Gaban:	I've never heard of it.
8 Sonja:	That the stars and...
9 Gucci:	But if you read your… when you read in the newspaper...
10 Sonja:	...horoscope.
11 Gucci:	Sometimes they're right.
12 Sonja:	Yes, that thing ... boys are from Venus and girls from Mars, or whatever it was.
	(inaudible small talk)
13 Grebe:	Yes, that thing with the horoscope, I think it's true.
14 Gucci:	Yes, sometimes it's right.

Sonja's first statement (turn 2) that the movements of the planets may have an effect on humans leads to a demand for clarification from Grebe by asking *In what way?* (turn 3). The question seems to cause some uncertainty and Sonja avoids answering by saying *I don't know, but everything affects us in some way* (turn 4). However, Sonja does not clearly explain her view of how humans and planets could be interrelated. Her statement might also constitute an example of a situation, in which she uses an epistemological resource that assumes that it is not possible to be absolutely confident about the trustworthiness of any statement related to these issues, and the idea that everything is possible. This interpretation is reinforced when Sonja in the next utterance (turn 6) express*...you don't really know if it is true. Nobody knows.* On the other hand, she simultaneously expresses hesitation about her own statement by shaking her hand and saying *But it sounds a little ...* (turn 6). The discussion goes on when Gucci adds a statement about horoscopes and claims that *sometimes they're right* (turn 11). In doing so, she seems to support Sonja´s reasoning that the planets and the stars may influence or have an impact on humans in some way. Grebe also expresses some confidence in horoscopes (turn 13) and Gucci ends the discussion, confirming Grebes statement, by saying *Yes, sometimes it's right* (turn 14).

The first excerpt constitutes an example of a situation where some of the students and Sonja in particular uses a category of epistemological resources where it is not possible to make any confident or reliable statements about the scientific trustworthiness of the explanation models at all. This may also include situations where the students use epistemological resources, which express a view that everything seems to be possible and that it is impossible to be absolutely sure of anything related to these kinds of issues. The use of this epistemological resource occurs on several occasions (in one third of the groups) in the total data material and has therefore been categorised as a situation where students use *relativistic epistemological resources*. This does not imply that the students who use these recourses in this specific situation will necessarily use similar recourses in other situations.

In the next two examples (excerpts 2-3) the students in different groups discuss the causes of allergies and different explanation models related to allergy (Case A). The discussion in excerpt 2 is to some extent initiated by the teacher, when she is trying to encourage the students to compare the different explanation alternatives related to the case. The dialogue starts when Aslan takes the pendulum in his hand and says:

Excerpt 2

15 Aslan:	This? [holds the pendulum]
16 Teacher:	Hmm!
17 Aslan:	It is ridiculous. It only glows!
18 Mossa:	That method is ridiculous.
19 Nob:	All you get is a tired arm [laughs]

In excerpt 2, Aslan (turn 17) and Mossa (turn 18) express the view that the *pendulum* and *the method* [are] *ridiculous*. Even if the group is requested to give explicit arguments or a justification for their statements, no one in the group takes the

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discussion further on. A possible interpretation of the lack of discussion may be that the students are agreed on the negative value of the pendulum, which seems to result in a situation where further discussion seems unnecessary. However, it is also possible to interpret the situation as though the students are actually displaying a lack of ability to express why they not consider the pendulum a serious alternative. The next excerpt (3) constitutes one of the examples where one of the students tries to take the discussion a step further by asking the others in what ways the pendulum possibly may have an impact on the human body.

Excerpt 3

20 Per:	This pendulum doesn't work. Do you think it works?
21 Elle:	Why?
22 Per:	How can it affect your body..?
23 Per:	...there's nothing in the pendulum that goes inside and kills the bacteria. How can it [the pendulum] kill them?

The discussion begins in a similar way as the discussion in excerpt 2, but Per tries to find a possible solution to the assignment by asking the others *How can it [the pendulum] affect your body?* (turn 22). No one in the group reacts to his invitation so he finally chooses to answer the question himself by seeking a logical connection between the pendulum and the body. But no one in the group takes the opportunity to discuss the issue further. Per's reasoning about allergies and bacteria is of course not scientifically correct (turn 23) but the statement clearly indicates a cause-effect view which may be seen as a kind of logical reasoning, despite the erroneous conclusion.

Thus, excerpts 2-3 may constitute some examples of an approach that several of the students display when it comes to relating their explanations to arguments about scientific trustworthiness. This lack of scientific reasoning is common in the total empirical material (occurs in nearly all groups), and the students often express what they believe in through the use of everyday language or with the help of normative statements without any clearly expressed justification. In this way, this kind of reasoning has been categorised as the use of *normative epistemological resources*. In this category, the similarities between the utterances are the use of resources above all seems to be related to traditions, preconceived opinions or general normative reasoning and rarely consists of references to scientific knowledge or trustworthiness at all.

However, some of the students use epistemological resources as they relate arguments to some kind of justification. In excerpt 4, the students discuss the scientific explanation model that was given in the case about allergies (Case A). The students are requested to read the text used to explain the scientific view of the disease and the possible cure. The excerpt (4) starts when Mossa expresses a general statement of what he thinks of the scientific explanation model, without any further justification.

Excerpt 4

24 Mossa:	I think it's right.
25 Jenny:	It's good
26 Bast:	It looks right to me.
27 Aslan:	Justify your answers!
28 Mossa:	It seems reasonable.
29 Jenny:	Because it's scientists that have put it forward. We're studying the science programme in order to know things like that.
30 Aslan:	But is it only researchers that can be right... and not other people?
31 Jenny:	Yes.
32 Aslan:	How is that?
33 Jenny:	What do you mean by...?
34 Aslan:	But answer the question.
35 Jenny:	Can you cure allergy with that thing that hangs... [Refers to the pendulum]
36 Aslan:	No, it's quite ridiculous.

The first statements in this example actually only display some general statements of what the students think of the scientific explanation. The discussion gathers some speed when Aslan asks the group to *justify* their answers (turn 27). The call for justification seems to produce the use of other kinds of epistemological resources and Jenny clearly articulates her view; *because it's scientists that have put it forward* (turn 29). Additionally, she asserts their own responsibility *to know things like that as students at the science programme* (turn 29). She uses this kind of resource on several occasions throughout the discussions and by that asserts the idea that the students have to be sceptical about non-scientific explanations. Jenny seems to use the argument that *scientists put it forward* as a strong motive to trust one of the proposed answers in the case. This is an obvious reference to an authority, which seems to be relatively common in the discussions throughout the data material. Other examples of the use of these references to authorities are found in excerpts 5 and 6. In these excerpts the reliability of the prescribed medicine, mentioned in case A, is in focus.

Excerpt 5

37 Elle:	They work [the tablets] because they sell them at the pharmacy.
38 Teacher:	How do you know they work?
39 Per:	Because people buy them. If they didn't work, people wouldn't buy them.
40 Teacher:	But how do you know that they work?
41 Per:	Because people buy them and get well.

Excerpt 6

42 Rocky:	If this [the pendulum] had worked they would have sold them in all the pharmacies. Have you ever seen this in a pharmacy?
43 Annelie:	No
44 Per:	Good argument, Rocky!

In the excerpts it is obvious that the argument – if a medicine is sold at the pharmacy or not– seems to be important for the judgement of the level of trustworthiness, as Elle (excerpt 5, turn 37) and Rocky express (excerpt 6, turn 42). However, it seems to be possible to use this argument in different ways. In excerpt 5, Elle argues that *they [the tablets] work because they sell them at the pharmacy* (turn 37) and in excerpt 6 Rocky uses the same argument in a discussion about the pendulum by saying *If this had worked they would have sold them in all the pharmacies* (turn 42). In this way they seem to express the view that when a prescribed medicine is allowed to be sold at the pharmacy, it automatically implies that the medicine is trustworthy. The students do not exactly describe what this means or what testing procedures the medicine has to go through before becoming licensed to be sold at the pharmacy, despite the fact that the teacher asking for more information. In this way it is possible to assert that the students' use of the argument – if the medicine is sold or not at the pharmacy – as an authoritative argument without describing the scientific process behind the development of the medicine. The term 'authoritative arguments' may be understood here in the students' references to different actors engaged in scientific procedures, traditions or cultures, without giving any further explanations of the trustworthiness. This may also include the reference to people's own market evaluation and behaviour as Per argues in excerpt 5 (turn 39 and 41) that *people buy it* and If *they didn't work, people wouldn't buy them*. By this statement he seems to point out that people buying them is a sufficient argument for evaluating the trustworthiness of the medicine and its effect.

The way the students use epistemological resources in these excerpt differs from earlier categories and is therefore labelled as the students' use of *authoritative epistemological resources*. This category constitutes the use of epistemological resources that refers to scientific authorities or cultures without discussing what the actual scientific trustworthiness may comprise of. In this way, it is the individual that states who the authority is.

On some occasions, the discussions of trustworthiness seem to evolve further and relate to different scientific activities, such as research, or the specific scientific content. In these situations, the students seem to use their epistemological resources in another way than in earlier examples. Excerpt 7 is the continuing discussion from excerpt 2. The teacher initiates the discussion about the explanation models in case A.

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Excerpt 7

45 Teacher:	What is the difference between these two? Which of them would you recommend and why?
46 Aslan:	Answer two, because that is something professionals work with [referring to the scientific explanation model].
47 Jenny:	Exactly!
48 Mossa:	They have to know something, before they take out something. They can't just… if they don't know something, they have to do research.
49 Jenny:	They know how the substances - the ingredients - react with the cells and so on.

In excerpt 7 where the students discuss the assignment on allergies (Case A), Aslan refers to *professionals* (turn 46) when he is requested to argue for which of the models he could recommend. Additionally, Mossa and Jenny use references that relate to the *research process* and to the scientific *content* (turn 48 and 49). This implies that Mossa argues that before professionals can make any statements about a substance *they have to do research* (turn 48). Jenny supports Mossa's utterance by saying; *they know how the substances - the ingredients - react with the cells and so on* (turn 49). In this situation, she uses scientific terms or concepts such as *substances* and *cells* and doing so shows that she is able to use them in a relevant way. This type of argumentation, which explicitly refers to scientific processes or content, is relatively sparsely represented in the students' discussions throughout the data material. One obvious explanation of this phenomenon may be that the teacher is present and her question to the students has an impact on the discussion.

In the next excerpt (excerpt 8) the discussion about the medicine and the pharmacy goes further in that some of the students refer to the scientific processes behind a new medicine. Excerpt 8 is the continuing discussion from excerpt 5 and the teacher is present.

Excerpt 8

50 Per:	Because people buy it and get well.
51 Teacher:	But how did they know... before it was sold at the pharmacy?
52 Per:	It was approved.
53 Annelie:	Guinea pigs!
54 Per:	It has to be approved before it can be sold, doesn't it?
55 Teacher:	But what do you do when you approve it then?
56 Elle:	Guinea pigs!

When the teacher asks for a clarification or an explanation of the commoditisation process for medicine, Per and Annelie refer to the fact that the medicine is tested before it is *approved* (turn 52 and 54). By doing this, Per seems to use other resources compared to the arguments he used in excerpt 5 (turn 39 and 41). Annelie (turn 53) and Elle's (turn 56) statements also indicate that they are familiar with a sci-

entific process by referring to the use of *guinea pigs* in the research process of the approval of medicines. This situation, compared to the situation in excerpt 5 may constitute an example where the same students may use different argumentative or epistemological resources on different occasions. We will return to this discussion later on. In this specific case, it seems that the teacher's demand for further clarification has an impact on the students' use of new resources.

As mentioned, the use of a developed scientific language and explicit scientific explanations are relatively rare in the discussions between the students. The fact that they sometimes use scientifically accepted terms or words do not necessary implies that they were able to use them as arguments in the discussion. However, the examples in excerpts 7 and 8 may constitute situations where the students actually are able to use some scientific references, such as the approval of medicines, the scientific content, research methods and the use of laboratory animals. However, this does not imply that the students were able use all of these references in a scientific, relevant way, but rather that they are able to use some of them as an argumentative resource in this specific situation. When students use their epistemological resources in this way we have labelled them as they use *scientific epistemological resources*. Unfortunately, there are relatively few statements in the empirical material that can be placed in this category.

In all, four categories of the different use of resources were identified in the data material; *relativistic, normative, authoritative* and *scientific epistemological resources*. As mentioned, it is possible to conclude that the students may use different epistemological resources on different occasions or situations. For example, when the same students (in excerpt 5) at first used authoritative epistemological resources when discussing the case about allergy and later on, challenged by the teacher, changed direction in order to use scientific epistemological resources. These changes commonly occur in the total data material and most of the students use several of the described categories in different situations. Consequently, the use of different epistemological resources should not be understood to imply that the use of one of them automatically excludes the use of the others. Additionally, they may not be understood as individual or mental entities but rather as the *repertoire* of the epistemological resources students are able to use in specific situations. Further, the described categories should not be understood to be the only ones possible. They instead constitute the epistemological resources the students used in this study, and we can assume that more of them probably exist.

DISCUSSION AND IMPLICATIONS

We have in this study used the framework of Hammer and Elby (2003), Hofer (2004a), Hofer and Pintrich (1997) in order to explore what kind of epistemological resources upper secondary students use when discussing different explanation models about phenomena related to the human body and health. The aim has, above all, been to analyse and assess the students' use of the concept of trustworthiness and reliability in relation to scientific as well as non-scientific explanations.

To some extent, this framework may be described as divergent from the commonly used frameworks in the science education research community. Cobern (2000), for example, argues that the individual's worldview is mainly established in early years and constitutes the fundamental organisation of the mind influencing how we view, act and argue in and about the world. From this perspective, students' ideas and their understanding of issues about scientific trustworthiness are viewed as a kind of individual property, which constitute a rather stable, mental entity.

In contrast to this view, Hammer and Elby's (2003), Hofer's (2004a), Hofer and Pintrich's (1997) framework describes the students' world view and their personal epistemology being situated and embedded in the specific situation the students encounter, and that they may use different resources dependent on this specific situation. From this perspective the epistemological resources the students are able to use may rather be understood as the repertoire of the resources students is capable of using specific situations or when working with specific issues. We argue that these ideas may, to some extent, be used in order to understand the phenomenon that students use different explanation models in, for example, school contexts and in everyday contexts, as several studies indicate (e.g. Hansson, 2007; Lundström & Jakobsson, 2009; Shermer, 2003). It is possible to discover a similar pattern in this study. Most of the students use different kinds of epistemological resources on different occasions and in relation to different issues when discussing the trustworthiness of the explanatory models. The used epistemological resources were mainly connected to sources of knowledge and justification of knowledge (Hofer, 2001; Rizk et al., 2012). However, it seems to be necessary to carry out additional studies in order to address these issues further.

Nevertheless, the framework of Hammer and Elby (2003), Hofer (2004a), Hofer and Pintrich (1997) has offered an opportunity to analyse what kind of epistemological resources the students actually use when they are involved in discussions related to scientific trustworthiness. In this way, the different resources have been categorised as relativistic, normative, authoritative and scientific epistemological resources. We argue, the categories should not be understood as the only ones possible. Rather, they constitute a starting point in order to develop an analytic tool that may contribute in deepening our understanding of how individuals perceive issues related to the nature of science and scientific trustworthiness. Such a tool may also help clarify issues related to the phenomenon that individuals are to be able to use scientific knowledge in a school context without making them their own, or as a part of their worldview, as Hansson (2007) reveals in her study.

The dominating category utilised by the students in this study has been the use of normative and authoritative epistemological resources. The students often express what they believe through the use of an everyday language, referring to traditions, preconceived opinions or general normative reasoning without any clearly expressed justification or references to scientific knowledge or trustworthiness at all. In addition, when they did not utilise normative resources they instead demonstrated a tendency to use authoritative resources. They refer to scientific authorities, cultures or other sources without discussing wherein the actual trustworthi-

ness consists. The results may be seen as surprising, especially as the students in this study participate in the science programme in upper secondary school. Several other current studies show a similar picture. For example, in Kolstø's (2001) study it was, above all, normative or authoritative statements that were utilised as sources of trustworthiness and these references were seldom challenged or criticised in the discussions. In addition, Sadler et al's (2004) study shows that nearly half of the students have the tendency to overestimate the scientific value of articles that supported their own original idea. Very few of the students in these studies raised questions about closely related research or if other research studies have come to the same conclusion.

The implications of this study could therefore be related to two different, but interrelated conclusions. Firstly, our study and several others, once again highlight the necessity to focus on issues about the nature of science and trustworthiness in science curricula and in science education at different levels. It is obvious that the students in our study express a lack of experience working with these kinds of assignments and that they need support and tutorials about how to evaluate the scientific trustworthiness of different explanation models. On some occasions, the teacher explicitly facilitated and deepened the discussion by raising open-ended questions and by pointing to the differences in the explanatory models, which probably had a positive impact on the discussion in these groups. This highlights the question of how to introduce and organise the instruction on these matters in science education. One possibility is to discuss pseudo-scientific issues in relation to science. If pseudo-scientific explanation models will be examined instead of ignored in science classrooms this could provide possibilities to enhance critical thinking and create opportunities to explore and develop an understanding of the nature of science. We think this way of working with cases and group discussions are opportunities to discuss and investigate the epistemology of science; science as a way of knowing, which is an important part of NOS.

Secondly, the study asserts the suggestion from Hammer and Elby (2003), Hofer (2004a), Hofer and Pintrich (1997) of considering student interpretations of scientific trustworthiness in their use different of epistemological resources. We argue that this framework may contribute to further increase the understanding of how students experience issues related to the nature of science and scientific trustworthiness in the future.

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