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"I have chosen another way of thinking"

Students' Relations to Science with a Focus on Worldview

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Abstract The article builds upon a study where students' relations to science are related to their worldviews and the kind of worldviews they associate with science. The aim of the study is to deepen our knowledge of how worldview and students' ways to handle conflicts between their own worldview and the worldview they associate with science, can add to our understanding of students' relations to science. Data consists of students' responses to a questionnaire ($N = 47$) and to interviews ($N = 26$). The study shows that for students who have a high ability in science, those who have taken science-intense programmes in upper secondary school to a higher extent than others have worldviews in accordance with the worldviews they associate with science. This indicates that students who embrace a worldview different from the one they associate with science tend to exclude themselves from science/technology programmes in Swedish upper secondary school. In the article the results are presented through case studies of single individuals. Those students' reasoning is related to the results for the whole student group. Implications for science teaching and for further research are discussed.

1 Theoretical Framework and Aims

1.1 Background

In a recent number of this journal science, worldview and science education have been dealt with in different ways (Science & Education 2009, 18(6–7)). Most of these articles are theoretical/philosophical and discuss for example the important question of whether or not science has a worldview. From earlier studies we also know that worldview issues are of relevance for the students (Hansson and Redfors 2006a, b). Here we would like to add to the discussions by reporting from an empirical study addressing the relationships between students' worldviews and their relations to science. Doing this we will also address the kind of worldviews that the students associate with science.

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1.2 Students' Relations to Science

The low interest in school science among youths, and their tendency of not choosing science profiles in school are today acknowledged as a major problem in western societies (Osborne and Dillon 2008; EU 2004, 2005; Jacobs and Simpkins 2005; Sjøberg and Schreiner 2005). To a great extent the societal concern and debate are built upon a combination of research indicating a scientific ignorance in the general public, and a view that scientific knowledge is of big economic importance for the society (Osborne et al. 2003). This concern has led stakeholders to initiate projects with aims to provide all citizens with science literacy, and positive attitudes towards science, but also to increase interest in science studies among youths. For example the European Union, governments in many countries and Academies of Sciences have invested in many such projects.

For the science education research community this concern has led to studies of students' interests in and relations to science, as well as on trying to understand students' choices and no-choices of science intense studies and occupations. Research has shown that interest and choice of study profiles are complex phenomena, and that they depend on many different factors (Lindahl 2003; Lyons 2006). They can be grouped as *individual variables* such as cognitive factors, personality and sex, *school variables* as interaction, instruction and teachers, and *structural variables* as social and cultural background and factors in society (Gardner 1975; Schibeci 1984; Lindahl 2003). Looking at different variables it seems as almost everything may influence attitudes and interest but it is difficult to assess the relative strengths of different factors (Lindahl 2003).

Research has also shown that students can very well appreciate for example the outcomes of science and technology even though they themselves do not want to engage in science studies or occupations (Schreiner 2006). In the literature a difference is often made between students' interest in science and in school science. In this article we focus on science rather than school science. Having said this, students' views of science are of course to a rather large extent depending on views explicitly or implicitly communicated in science class. Aikenhead (1996) describes it like this: *"the subculture of school science always conveys images of science as a subculture, even though science educators may pretend that it does not, or may disagree over those images"* (p. 11).

Stenmark (2004) considers another factor relevant when discussing young people's possibilities to engage in and identify themselves with science. He states that as science is not a worldview or ideology neutral enterprise it is essential to provide students with examples of people with different ideologies and worldviews engaged in science, to make it easier for students with different worldviews to identify themselves with the scientific enterprise. The concept of identity can be defined in different ways. Here we follow Aikenhead (2006) and use the concept with the meaning *"who they are, where they have been, where they are going, and who they want to become"* (p. 108). This is also in line with Brickhouse (2001) and Schreiner (2006), see below. That worldview can be an important factor to consider when to understand students' possibility to identify themselves with science, and to understand why students choose to engage in science studies or not is also expressed by Cobern (1991). He states that *"attitude and interest have cognitive roots, and thus are shaped by world view presuppositions"*. Through this study we want to take a starting point in this and address and investigate how worldview can be a factor when trying to understand students' relations to science.

1.3 Students and Worldviews

The concept worldview can be used in different ways. In the science education research field there are authors who use Pepper's "world hypotheses" (see Kilbourn 1980–1981, while others use a worldview theory formulated by Kearney (1984). Here we have chosen to use the theory by Kearney. This theory was used and described in a science education context by Cobern (1991, 1996). According to the model every worldview can be described by the content of seven cognitive categories or universals. Those are: Self, NonSelf, Relationship, Classification, Causality, Space and Time. In the present study the focus is upon the category "NonSelf". "NonSelf" is everything except "Self", and this is the first classification done. There are, however also classifications within "NonSelf". These classifications vary between individuals, for example between atheists, theists, and pantheists. A common classification is "Humanity (society), Nature, and God (the transcendent)" (Cobern 1991, p. 45).

The seven categories or worldview universals are always the same, but can consist of different presuppositions of what the world is like (Cobern 1991, 1996). For example the category "NonSelf" can, for different individuals, consist of different presuppositions. Examples of such common presuppostions in the category NonSelf are that nothing more than the material world exists, that everything has a meaning, that there are patterns in nature that are possible for humans to understand, and that a god exists and interferes in the world. An individual's presuppositions of what the world is like constitute a basis for how she/he thinks about and understands specific phenomena and models that she/he meets for example in the science classroom. Cobern (1996) says

> "Worldview provides a nonrational foundation for thought, emotion, and behaviour. Worldview provides a person with presuppositions about what the world is really like and what constitutes valid and important knowledge about the world" (p. 584).

Students' worldviews have been studied before (e.g. Cobern 1993, 2000a; Helve 1991). These studies show that students' worldviews differ between different students, but it is also shown that many students do not use a scientific description of nature in the first place.

1.4 Science and Worldview

In the present study we are, however not only interested in students' own worldviews in general, but also in what kind of worldviews the students associate with science (see also Hansson 2007; Hansson and Redfors 2007a, b). We take a starting point in that also all knowledge systems—for example science—are built upon presuppositions that are not possible to prove within the system itself (Cobern 1991, 1996; Trusted 1991). We view science as a culture (Aikenhead 1996; Phelan et al. 1991) with views (for example worldview presuppositions) and values, and we are interested in what the students think are views and values of science. The value of studies focused on what worldviews students' associate with science is pointed out by Säther (2003). He states:

> "In the future it seems to be a task to find out more about how children interpret the world picture given in a science education framework in relation to religious and spiritual dimensions" (p. 253).

The presuppositions that a student associates with science can very well differ from the student's own presuppositions of what the world is like. One example is that it is common that students associate "scientism"[1] (Poole 1998; Stenmark 2001) with science. This they can do even though they themselves do not share such a view (Hansson 2007; Hansson and Redfors 2006b, 2007a, b).

If science has a worldview, and in that case what constitutes this view is a question not agreed upon (see Science & Education 2009, 18(6–7)). There are people who state that science has no worldview, and that science is only an instrumental endeavour, while others state that science has a specific worldview. There are also researchers like Gauch (2009) and Lacey (2009) who state that science is worldview independent, but can have worldview import. Some of those who state that science has a worldview mean that the worldview of science is in conflict with religious views, while others state that science does not exclude religious views. What views concerning this one ends up in depend on the individual's views of religion, but also how she/he looks upon the nature of science (Glennan 2009) and the pretensions of science. However people, also scientists, have different views concerning the nature of science and more specifically what presuppositions (if any) that science builds upon. Alters (1997) states that "no one agreed-on NOS exists" (p. 48). Cobern (1991) states that.

> "The only way to avoid the conclusion that there is actually more than one scientific world view is to employ the distinction between lived and articulated world views. This distinction allows one to hold that while different articulations of a scientific view of the world, these people have in common a subset of lived presuppositions necessary for science." (p. 69).

Which these presuppositions are that scientists have in common, is a difficult question. Poole (1998) discusses which views that underpin science and states that scientists share the following views:

- "human reason is generally reliable,
- there is regularity and order in the universe,
- humans can discover and understand something of that order,
- there is a basic uniformity in the behaviour of the natural order, in space and time" (p. 186).

In a similar way Cobern and Loving (2000) describe a "metaphysical minimum for science" and state that science take a starting point in "the possibility of knowledge about nature", "that there is order in nature", and "causation in nature". Matthews (2009a) describes how "science presupposes at least methodological naturalism".

In this article we take as a starting point that there are presuppositions that underpin science of the kind that are described above. In addition to this kind of presuppositions most scientists add others (Cobern 2000a). This means that different scientists can come to different conclusions concerning existential questions built on the same scientific model (Cobern 2000a, p. 240), and that more than one worldview are compatible with science. For example "scientism" can be viewed as a worldview compatible with science, but this is valid also for many religious worldviews. This is in line with the discussion by Lacey

[1] Scientism can be defined in a number of different ways (see Stenmark 2001). The definition used here follows Poole (1998). He states that scientism but not science "Denies that anything other than the natural world exists", states that "Scientific accounts are all there are", "Denies that there are *first* causes or *final* causes", and "Denies that there could ever be behavior other than law like (anti-miraculous)" (Poole 1998, p. 195). This definition of scientism is similar to what Stenmark (2001) calls "Ontological Scientism".

(2009) who states that "the scientific attitude is not tied to any one worldview, materialist, religious or other".

One can see two extreme poles on a scale describing how school communicates worldview through teaching (Proper et al. 1988). In one extreme school presents a large variety of worldviews and discusses this explicitly, while in the other extreme school present a narrow span of worldviews, and do so implicitly. Kilbourn (1980), discusses worldview as part of the hidden curricula, and Roberts (1998) talks about how for example worldview is communicated implicitly as "companion meanings". Those implicit messages are important and students' views about the values and presuppositions of the science culture depend also on those.

1.5 Learning, Identity and Worldview

Learning science is not only about understanding specific phenomena or models. Costa (1995) relates how easy/hard transitions between home cultures and the culture of school science courses are to students' success. In line with this Brickhouse (2001) argues that science education must be understood as a process of shaping identities. She writes *"We need to know how students engage in science and how this is related to who they are and who they want to be"*. According to this, whether a person wants to be a part of science education and take the views of science as being her own, depends partly on how she views science in relation to how she views herself. Worldview presuppositions are closely linked to self-identity. Aikenhead (2006) states that *"Discordant worldviews* [between students and science (our comment)] *create an incompatibility between, on the one hand, students' self-identities/…/and, on the other hand:*

> students' views of Western science, school science, or their science teacher/…/, and students' views of the kind of person they think they must become in order to engage in science" (pp. 107–108).

In this study this becomes relevant if a student's own presuppositions of what the world is like differ from the ones that the student associates with science. Worldview presuppositions, as discussed above, are about how you view and understand the world. Brickhouse et al. (2000) states *"we have not sufficiently attended to the more fundamental question of whether students see themselves as the kind of people who would want to understand the world scientifically"* (p. 443). This way of viewing science teaching and learning as an identity issue, is also in line with the results in Worthley (1992). She has studied the connection between students' values, how they view science and their choice of study profiles. Her study shows that students who have chosen science profiles more frequently than others, have themselves values that are concordant with the ones that they associate with science. For students who did not choose to study science the differences are larger between their own views and the views of science. Krogh (2005) has studied the presence and significance of different kinds of "border crossings" concerning students' attitudes to physics, and their choice of physics courses. The study shows that the number of "border crossings" are important for whether to choose physics courses, and that the value-based issues is one of the types of "border-crossings" that to the greatest extent influence students' choice or no-choice of physics. Also Schreiner (2006) states that today a student's choice of study profile is at the same time a choice of identity. She concludes that interest among youths for science and for choice of science intense study profiles and occupations are part of their identity formation. Associating science with worldview presuppositions that students themselves do not share could then be thought to be a

problem, making them less inclined to identify themselves with the science community, and instead when they have a choice choose not to study science. The aim of the present article is to show examples of

> How students' worldviews and their ways to handle differences between their own worldview and the worldview they associate with science, can be a factor when trying to understand students' relations to science.

2 Design of the Study

2.1 The Students in the Study

School in Sweden is compulsory between the ages of 7 and 16. During these years about 10% of the teaching time is for science. At the age of 16 almost all students continue onto upper secondary school where they can then choose between 16 different programmes. If they later on want to study science or technology at the university, they have to choose the "Natural science", and "Technology" programmes (National Agency for Education 2000) with much mathematics, biology, chemistry and physics. Less than 20% of the students do so. Other programmes in upper secondary school are the "Social science" programme, which also prepares for university studies, the "Arts" programme, and different programmes preparing for working life. Some courses are compulsory over all programmes, so students at all programmes study basic courses in English, Arts, Physical Education and Health, Mathematics, General Science, Social Studies, Swedish and Religion (non-confessional).

Our sample is a group of students followed in an earlier longitudinal study from the age of 12–16 (Lindahl 2003, 2007). The focus of that study was how and why students' attitudes to science change during the second half of compulsory school. This research has been used to understand the reasons for choosing or not choosing programmes with a science/technology profile in upper secondary school. In the study presented in this article we explore whether worldview can be a factor that can add to our understanding of those students' relations to science. In the present study the students are 19 years old and just about to leave upper secondary school.

From the first longitudinal study, we have information from observations in the classroom, questionnaires, and, interviews. As a measurement for ability for further studies in science an inductive-logical test (Härnqvist 1998), which in several studies have been used successfully, was used together with students' marks in mathematics and science (Lindahl 2003). From this longitudinal study we have information on how each student's interest in science has changed, and how they have reasoned about science, education and what they want to work with when they have grown up. The focus of the analysis that this article builds upon is, however on the new data collected. The longitudinal data is in this study used as a background.

2.2 Data Collection and Analysis

In the new data collection the students were asked to answer to a questionnaire sent to them by mail (47 out of 61 students answered) about school, science, worldview and their future. Concerning worldview the students were asked to state whether they agree or not (on a four-point Likert scale) with 30 statements (see Table 1 in Appendix A). The statements

are about the content of the worldview universal "NonSelf" (Kearney 1984; Cobern 1991). The choice of instrument depends on our interest in finding students that themselves do not share the worldview they associate with science. Earlier studies (Hansson 2007; Hansson and Redfors 2007a) show that it is common that students when asked about scientistic as well as traditional religious statements answer in different ways when asked about their own view and when asked about the view of physics. In this study we also include new religious statements—that is views that are commonly associated with new religious movements, for example New Age. Students were also asked to decide whether the same statements were (1) supported by science, (2) contradicted by science or (3) neither supported nor contradicted by science. With this design, we are open for the possibility that students could hold a personal view different from the view they associate with science. This has been seen in earlier studies (Hansson and Redfors 2006a, 2007a; Dagher and BouJaoude 1997; Brewer and Chinn 1991), and is also in agreement with Cobern's (1996) view that an individual could very well *comprehend* a view without *apprehending* it; that is, take it to be the view of her/his own.

Many of the scientistic statements and the traditional religious statements have been used before by Hansson and Redfors (2007b). In the construction of those statements we took a starting point in the results from a survey and interview study (Hansson and Redfors 2006a, 2007a), and were also inspired by Poole (1998). The other statements were constructed for this study. They were inspired or borrowed from Sjödin (1995, 2001, 2002), or constructed with inspiration from books about new religious beliefs (Arlebrand et al. 2003; Hammer 2004).

As a complement to the questionnaire, interviews (about 1 hour each) were performed with 26 students with the aim of gaining deeper and broader knowledge of their views and reasoning. Except for worldview the interviews addressed students' views about school, their interests in science, and how they look upon their choice of study profile for upper secondary school and their plans for the future. The worldview part of the interview consists of, inspired by Cobern (2000a), a discussion concerning statements written on cards (see Table 2 in Appendix B for the statements). Also in the interviews the statements are about the content of the worldview universal "NonSelf" (Kearney 1984; Cobern 1991). Some statements were the same as in the questionnaire, while some statements were new in the interviews. In the same way as in the questionnaire and for the same reason (see above), the students were to state both their own view and whether each of the statements were (1) supported by science, (2) contradicted by science or (3) neither supported nor contradicted by science. When the student has sorted all cards we related to the cards on the table in front of us and asked her/him about how she/he feels about the differences between their own view and the view of science.

In an earlier article (Lindahl and Hansson 2009) we have presented the results from the questionnaire on a group level. In this article we focus upon data from the interviews, and show examples of individual students' reasoning. We are especially interested in students with a worldview that differ a lot from the one they associate with science. In the article eight students are described. They have been chosen from their answers to the worldview part of the questionnaire (see below), and could therefore be related to the whole student group. The description of the students were constructed from the interview transcripts together with their answers to the questionnarie. As an example one students' answers to the worldview part of the questionnarie, together with the way she sorted the cards during the interview are included (see Appendix C). This makes it possible for the reader to get some idea about the relationship between questionnarie/card sorting on the one hand and the description of the student on the other hand. However it is important to notice that students'

card sorting not give all information given by the interview concerning the statements. The students are sometimes reasoning back and forth concerning a statement, and this reasoning gives us more information than solely the final placement of the card. Quatation from the students are shown to exemplify students reasoning for example about the ways they view conflicts between their own view and the views they associate with science. Both authors have been engaged in and agreed on the descriptions of the students. The second author has also an earlier knowledge of the students from repeated interviews over many years.

3 Results

3.1 Overall Picture

The number of conflicts between students' own views and the views they associate with science differ to a great extent between different students, see Fig. 1. By a "conflict" we mean that a student states that she/he agrees with a statement but states that science contradicts it, or that a student disagrees with a statement but states that science supports the same statement. When a student states that science neither agrees nor disagrees with a statement, there is no conflict. Neither is there a conflict when the students' view is supported by science (for example, a student states that science agrees with a statement with which the student also agrees). In this part of the analysis we have only included students who have expressed both their own view and the view of science for more than 25 of the 30 statements ($N = 40$). It is important to notice that by "conflict" we mean that the student state different views when describing her/his own view and the view of science. Whether or not this is a problem for the student is not taken into consideration at this stage of the analysis. There are students that have no conflicts at all, and students that have conflicts for more than half of the statements (Lindahl and Hansson 2009).

We have looked closer into a group of students who, when about to leave compulsary school, have been categorised as having high ability for science. Among those students we have seen a difference on a group level, between students that have and have not taken a science intense study programme in upper secondary school, concerning the amount of conflicts between their one worldviews and the ones they associate with science. High ability students that have taken a science intense programme to a higher extent than high ability students that have taken other programmes have worldviews in accordance with the worldviews they associate with science (see also Lindahl and Hansson 2009 and Fig. 2).

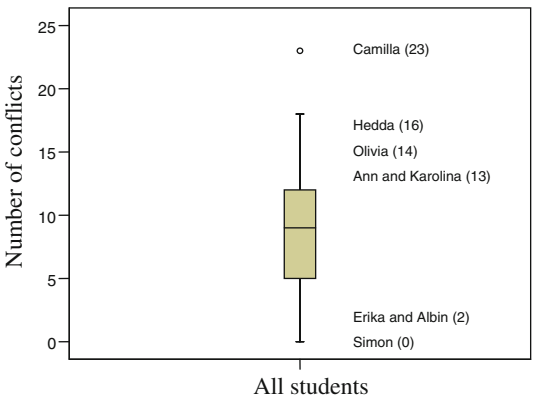

Fig. 1 Number of conflicts between students' own view and the view they associate with science, concerning the 30 statements in the questionnaire, for all students ($N = 40$) in the study. The *horizontal lines* of the box show the 25%-, 50%-, and the 75%-quartile. The students mentioned in the figure are discussed in the article

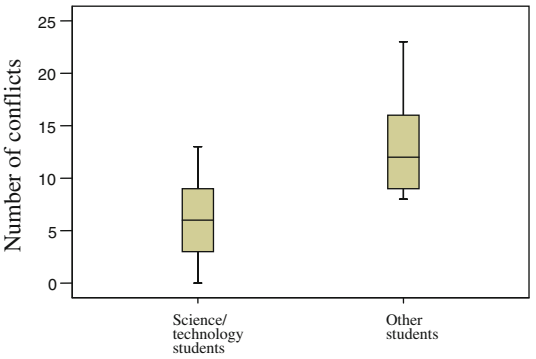

Fig. 2 Number of worldview conflicts for high ability students ($N = 23$) that have a science/technology profile in their studies (science/technology students), and the students that have other profiles (other students). The *horizontal lines* of the boxes show the 25%-, 50%-, and the 75%-quartile. Differences were found between the groups in relation to average conflicts ($p < 0.01$, Mann–Whitney $U = 23.5$, $Z = 2.5$) Mean ranks were 7.6 and 14.8 respectively) The strength of the relationship was found to be rather high ($r = 0.52$)

This result could be understood from viewing students' relations to science as an identity issue—where worldview is one part. Cobern (1991) states that *"attitude and interest have cognitive roots, and thus are shaped by world view presuppositions"*. We will in this article discuss the relations to science and compare students with many respective few conflicts in the questionnaire (Fig. 1). Few respective many conflicts in the answers in the questionnaire is not an absolute answer to the level of difference between the worldview of the student and the worldview she/he associate with science, since it is impossible to cover every possible aspect of worldview in such a questionnaire. Nevertheless it gives an indication, and one can suspect, built on the possible relationship between worldview and interest (Cobern 1991), that students that have many conflicts in the questionnaire have a more complicated relation to science than students with a low number of conflicts. To get a deeper understanding of whether this is the case and what this can look like we will below discuss the students with the highest respective lowest number of conflicts.

3.2 Students with Few Conflicts–Albin, Erika and Simon

Among the 9 students with few conflicts,[2] four have studied science intense programmes, and five of them have not. Among the students who have not studied a science intense programme in upper secondary school we have interviewed Albin, Erika and Simon.

Albin, Erika and Simon have worldviews that are in accordance with the worldview they associate with science. Concerning the statements that consitute necessary presuppositions for science Simon and Erika agree or do not know, while Albin answers in different ways for the different statements. All three students to a large extent disagree both with traditional and new religious views. They agree more with the naturalistic statements, especially Erika and Simon.

Students' interest in science and choice of study profile for upper secondary school depends on many different factors, referred to above in the background section of the article. When studying Albin, Erika and Simon in more detail we can see that those factors

[2] "Few conflicts" is defined as less than the 25% quartile—that is less than 5 conflicts.

described in the literature can describe why they have chosen not to study science. Albin has been categorised as having low ability (see above) for science studies when he was about to leave compulsory school (Lindahl 2003), which is probably an important factor when to explain his choice. In the interview with Erika it is obvious that her difficulty with mathematics is an important factor for her not considering a science programme for upper secondary school. She is not uninterested in science, and she has a high trust in science. Simon is a student that had probably managed a science intense programme in upper secondary school. He is also interested in science, and he reads popular science magazines. When discussing his choice of study profile in upper secondary school he says that he probably had not coped with science studies in upper secondary school—that is some kind of strategic reason. He also states that his interest in social science is higher than his interest in natural science. For none of these three students their no-choice of science/technology programmes in upper secondary school can be explained by disinterest in science, but rather in low ability for science studies, difficulties with mathematics, strategic reasoning and an even bigger interest in other subjects.

3.3 Students with Many Conflicts

We will now turn to the 9 students that have most conflicts.[3] Among those, two students have studied a science intense programme in upper secondary school, the others have not. One of these two students—Ann—regrets her choice of study profile, and she has chosen to study as little science as possible at the programme she takes. Ann says that she because of her dislike of physics and chemistry has chosen to take courses in mathematics and computer science instead of more science courses than what is compulsory at the programme.

Ann is ambivalent concerning the traditional as well as the new religious statements. She agrees with some of them, disagrees with others and sometimes changes her mind between questionnarie and interview. Concerning the naturalistic statements the over all picture is that she disagrees. Mostly the conflicts present are for traditional religious respective naturalistic statements. Ann says that she does not see the meaning with the science subjects. Concerning the statements about the necessary presuppositions of science she disagrees or does not know. For example she views the universe as incomprehensible, which she states that science contradicts. She also does not agree with that the best way to get knowledge of the universe is to start with the parts. She states that one has to start with the whole picture. Science on the other hand, she says supports such a view. She states that science is more interested in the parts. We will come back to the other student Olivia later.

Among the students with many conflicts there are altogether 6 students that have been categorised as having high ability for science, but who nevertheless have chosen to study other programmes. We have interviewed three of them—Camilla, Hedda and Karolina. These three students have all high ability for science when about to leave upper secondary school, but none of them have chosen to take a science intense programme.

The descriptions of the reasoning of Camilla, Hedda, and Karolina will show how worldview and differences between students' own worldview, and the worldview they associate with science could be a factor when trying to understand why these students do not find science studies attractive. We will also relate these three students' reasoning to the reasoning by Olivia who also has a lot of conflicts, but nevertheless has chosen to study science and seems happy with her choice of study profile.

[3] "Many conflicts" is defined as more than the 75%-quartile—that is more than 12 conflicts.

3.3.1 Camilla

Camilla had high ability for science when about to leave compulsory school, and she had probably managed science studies in upper secondary school. However, during the last years before her choice of study profile her interest in science became low. She has also chosen not to have a science profile in her upper secondary school studies. Instead she has studied the "Art" programme. There are probably many different factors behind Camilla's choice not to take a science intense programme. For example she has heard that the science programme was a hard programme, and she states that she at the time did not want to study that much. Another explanation can be that she finds mathematics boring. But yet another explanation could be, and here Camilla differs from the students described above (Albin, Erika and Simon), that she states that she does not like chemistry and physics (biology she finds somewhat more interesting). She says that she has always had difficulties with the science subjects, and she does not see the logic. When looking closer into how Camilla describes her worldview and the worldview she associates with science we can come closer in understanding why she believe that science is not a subject for her.

Concerning the worldview questions Camilla, both in the questionnaire and the interview, states a view of her own that most often is contradicted by the view she associates with science. Camilla is very open for other dimensions of the world than the material, and agrees both with traditional religious statements and many of the new religious statements, but disagrees with the naturalistic statements—that is statements associated with scientism (see above). Her views are in conflict with the views she generally associates with science since she states that science supports the naturalistic statements and disagrees with the religious ones. Camilla does not believe that everything has a scientific explanation, a view that she associates with science. She states that science only believe in logical things—in things that one can "see and feel and hear". Concerning the statement "*If you want to understand the whole universe, the best way is to try to understand every phenomena separately"* she states that science supports this. Even though she in the questionnarie states that she herself also agrees, she in the interview states that she disagrees. She states that she does not believe that the universe is comprehensable at all, so it is not worth the effort. Opposite to the view she has herself, that the universe is incomprehensible, she states that science views the universe as possible to comprehense:"*If not you would not put that much time and energy on understanding it"*. She does not seem to understand or share "the project of science"[4] :

Camilla: I don't understand why one tries to understand something I think one will never do. Humans believe that she is capable of much more and is much more than she really is

She states that science isn't her subject and that her not believing in everything in science influences this:

Camilla: I don't think science is fun and I don't know exactly why, it just isn't my subject. And then that I don't believe in everything that is said have an effect
Interviewer: It doesn't feel that urgent?
Camilla: No

[4] With the "project of science" we mean the belief shared by researchers, that knowledge about the world is possible to gain and is worth the efforts. Also a belief in that knowledge is possible to gain through methodological reductionistic approaches.

Camilla states that her disinterest in science might have been influenced by her not believing in everything in science. This together with her not believing in or sharing the "project of science" are probably two explanations for her not being interested in science, and explanations to why she although she has high ability for science did not seriously consider to take a science intense programme in upper secondary school. In Camilla's case it is obvious that worldview lies behind her disinterest in science, which is in line with the reasoning by Cobern (1991).

Camilla has many conflicts between her own worldview and the worldview she associates with science, and believes that her disinterest in science is influenced by that. However, there are students that even though they have many conflicts like that have chosen to take the science programme and seem more or less happy with their choice. Olivia is such a student.

3.3.2 Olivia

Olivia's ability for science studies was categorised as "average" when about to leave compulsory school. In upper secondary school she has studied the "Science programme", and states that she is happy with that choice. Olivia is interested in science, especially biology and chemistry while physics is rather interesting. After upper secondary school she wants to continue her science studies to become a pharmacist. Just as Camilla, Olivia has conflicts between her own worldview and the worldview she associates with science. She views science as a kind of faith:

Interviewer: The view of science you presented. How do you think about it?
Olivia: They have their own beliefs. The beliefs of science. And I have no problems with it, that is some things can be true, so I have nothing negative or positive about it

Olivia's religious belief is important to her, and she feels free to believe in some things that science says, but choose not to believe in other.

Interviewer: In some cases you agree with science, in others you don't. How do you feel about that? Do you feel it is difficult?
Olivia: No, it isn't. That is everyone believes. I think that everyone agrees with something. You can't contradict this because of your own religion—and all they say is wrong. That is also wrong
Interviewer: But you don't need to believe in all that science says? You can choose to believe in what you feel is okay in science and other things you can let go. Is that how you think? [The student confirms during the time the interviewer speaks]
Olivia: Yes

This view that she as an individual is free to choose what to believe in—that she does not feel "forced" to believe in everything she associates with science—is probably important for her being able to engage in science studies, even though she has a lot of conflicts between her own worldview and the worldview she associates with science. Opposite to Camilla, Olivia also states that the conflicts between her own worldview and the worldview she associates with science are not something that influences her interest in science negatively:

Interviewer: That there are differences between how you think and how science views things, does that make you more or less interested in science, studying science and such things?
Olivia: No, you are always interested in it. Get to know how far they have come and what they have found out and so on. That is fun
Interviewer: So that does not influence the interest?
Olivia: No, no, it doesn't influence

What then is the difference between Olivia and Camilla? Can worldview help us understand why Olivia is interested in science and has chosen to take a science profile in her studies, while Camilla is not interested in science and has chosen to take another study profile? We argue that worldview can add to our understanding of the difference between Olivia's and Camilla's relations to science.

Olivia's conflicts are about her agreeing with traditional religious statements that she believes that science contradicts, and about the naturalistic statements on which she mostly does not agree, while science according to her supports such views. Also Camilla has conflicts concerning religious statements, but she also does not share the "project of science"—a project that Olivia does not seem to have any problems with. Camilla does not engage in the project of finding explanations to phenomena, but instead she states that she does not understand why one tries to find explanations to things when it would not succeed anyway. Olivia on the other hand finds it interesting to get to know about new findings, and also shares the view that we eventually will be able to understand the universe—a view that both Camilla and Olivia associates with science. Also opposite to Camilla, Olivia shares a belief in the procedure of the scientific enterprise—that is begin by trying to understand different parts, rather than begin by looking at the whole picture. This is probably an important factor in understanding why Olivia finds science meaningful while Camilla does not, that Olivia more or less shares the project of science, and believe in the way one tries to get knowledge of the world, while Camilla does not share the project, but instead finds it worthless.

In addition to this Olivia learns science in a "cross-cultural" (Aikenhead 1996) way where she states that you very well can take some views of science to be your own, while you choose not to believe in others. She has found a strategy where she can engage in science, and find the scientific enterprise meaningful and useful (e.g. in her future work), even though there are conflicts between her own worldview and the worldview that she associates with science. Camilla on the other hand states that her not believing in everything in science influences her interest in science negatively.

3.3.3 Hedda and Karolina

Both Hedda and Karolina have chosen to take the "social science programme" in upper secondary school. In the same way as Camilla's choice this could not be explained by their ability for science studies, since both of them have been categorised as having high ability for science when they were about to leave compulsory school. Both these students are more appealed by the social sciences than by the natural sciences. In this they reason in a similar way as Simon described above, and perhaps the reason for their choice of social science could—as with Simon—be described as built on a profound interest in those subjects rather than in a dislike of science. Nevertheless there are also differences between Simon on the one hand and Hedda and especially Karolina on the other hand, that can add to the picture. While Simon has a positive view of science—for example he enjoy reading popular science magazines, and has a worldview that seems influenced by science to a large

extent—Hedda and Karolina are sceptical in relation to the scientific enterprise which they believe builds on views that they do not themselves share.

Both Hedda and Karolina themselves agree with many of the traditional and new religious statements. Science according to them contradicts or neither supports nor contradicts those statements. Concerning the naturalistic statements the over all picture is that they do not agree with them themselves, but states that science supports or neither supports nor contradicts them. For example Hedda does not share the view that there are explanations to everything—a view which she associates with science. She states that the universe is meant to be incomprehensible for humans. Science, she says, wants the universe to be comprehensible, even though it is not comprehensible for us today. When trying to understand the universe she wants to look for the whole picture from the beginning, while she states that science starts with different parts.

Karolina states that she views the universe as incomprehensible, but states that she believes that science contradicts that. During the interview she explains that she has chosen a way to reason that is different from the way one reasons in science:

Karolina: There are surely people who find a meaning with it, with this way of thinking and reasoning and it is connected with science, but I don't think it gives me anything, but I have chosen another way of thinking and reasoning which fits better with the social sciences

Both Hedda and Karolina states that you yourself choose what to believe in. Karolina describes it like this:

Interviewer: Some things in your view of reality science contradicts. Do you feel a resistance towards science because of this or do you feel an interest because of it?

Karolina: No, this is just a question about beliefs, it ends up in, I think. You have certain fundamental things and then you nevertheless have a whole in same way, and some of these things you support and some I don't support and it does not need…yes

Interviewer: So, you think that science is a kind of belief system?

Karolina: Yes, I look at it that way, it is a belief in a reality system which they in some way with reason try to make real, but I think that everything could not with reason become real. Not in this life or in this situation

Such a view could have helped these two students to find a way to engage in science in a "cross-cultural" (Aikenhead 1996) way as in the case with Olivia. However, this is not enough for these students. Perhaps this has to do with a profound interest in social science. But the fact that they feel more appealed by social than natural sciences have a ground in a scepticism against the scientific enterprise, and Karolina explicitly states (se above) that she does not feel that the way one reasons in science is meaningful for her, and she has because of this chosen another way to think and reason.

4 Conclusions and Implications

The aim of this article is to explore worldview as a factor when trying to understand students' relations to science. The results indicate that there are reasons to take worldview serious when discussing why so many students believe that science is not for them. The study shows a difference between students with high ability for science that did and did not

have a science intense study profile in upper secondary school. High ability students on science/technology programmes have worldviews that to a greater extent are in accordance with the worldviews they associate with science than students on other programmes have. This indicates that students with worldviews very different from the ones they associate with science tend to exclude themselves from science intense programmes in Swedish upper secondary school (see also Lindahl and Hansson 2009). With a starting point in the results on a group level, we have in this article shown examples of the reasoning of individual students with worldviews that differ from those they associate with science. For some students those differences make their relations to science complicated, and the differences can for some of them also be part of the reason for they feeling that science studies is unattractive and irrelevant. Camilla states this explicitly.

The results presented in this article can be understood from the starting point that science learning is an identity issue (Brickhouse 2001; Brickhouse et al. 2000; Lemke 2001), and choice of study profile a choice of identity (Schreiner 2006). Students' relations to science are very much an identity issue, and worldview is probably an important part of this. In line with this Reiss (2009) states that "*avoiding science/religion issues, when they are of relevance to students,/…/may increase the chance that science remains irrelevant for some students, unconnected to their worldview*" (p. 793). If you as a student have a worldview that differ a lot from the one you associate with science it can be hard to identify yourself with science, and you tend to for example choose other study profiles and occupations that you feel (right or wrong) are more in accordance with your own way of viewing the world. Examples of such students are Camilla, Karolina and Hedda.

Both Camilla and Karolina changed their interest in science during compulsary school. Both of them have been more or less interested but during the second part of compulsary school their interest became low. From a worldview perspective a change of interest in science could depend on that the individual have had a change in worldview, but it can also depend on a changed view of science. For example Karolina says that in young years the science she met was almost like magic. Perhaps science classes focused on fun and exciting experiments, without really describing what happens can give a picture of magic—things suddenly change colour, it bangs and so on. Perhaps such things speak to a rather different (from a worldview perspective) group of students than the ones that are attracted by a scientific way to describe the world.

It is, however important to notice that differences between your own worldview and the one you associate with science is not necessarily a problem for all students. The students we have described here state that one can have a free attitude to science, meaning that you yourself choose what to believe in. In this way the differences between students' worldviews and the worldviews they associate with science themselves are not necessary a problem. On the contrary this is probably a way for some students to engage in science studies and find this positive, even though their worldviews differ from the ones they associate with science. Such a student is Olivia described above. She has taken a science programme in upper secondary school. She is happy with that study profile, although there are big differences between her own worldview and the one she associate with science. Her way to handle science is through "crosscultural learning" (Aikenhead 1996; Cobern and Aikenhead 1998). This means that she can learn about views of the culture of science, without taking all of them to be her own views, and without feeling that she should. Also Jegede (1995) and Baker and Taylor (1995) discuss the possibility to learn new views parallel to earlier ones. A student like Olivia, feel that science has strengths that makes it attractive—although she does not believe in everything that she associate with science. Olivia wants to be a pharmacist and has a strong interest in science, especially chemistry and biology. Olivia has probably invented a cross-cultural

learning strategy herself. An explicit cross-cultural teaching (Aikenhead 1996) would give more students than those who invent such a strategy themselves a possibility to learn science in a meaningful way, even though there are differences between their worldviews and the worldviews they associate with science (see also Hansson and Redfors 2006a). A student like Olivia shows us that it is not only about the amount of worldview conflicts, but also about how one manage to handle the conflicts.

Among the students that have many differences between their own worldview and the one they associate with science, there are examples of students for whom science does not become important. The way to view the world that they associate with science is too far from their own way of viewing the world. For those students the strengths of science does not become obvious. The differences between their own worldviews and the ones they associate with science make science studies an uninteresting alternative. In this article we have seen Camilla and Karolina, and to some extent Hedda as examples of such students. We argue that worldview for those students is important to take into account when trying to understand their relations to science, for example their lack of interest in science, and their choice not to take a science intense study profile. Those three students are all categorised as having high ability for science studies, and themselves feel that they are good at science when about to leave compulsory school. Those are factors often mentioned when discussing students' interest and choices (see above). Trying to understand Camilla's, Hedda's and Karolina's relations to science, we have showed that worldview can be a factor that could add to such other factors described in the literature. In some cases it could also be a way to understand some of those earlier mentioned factors. For example, being successful in science is easier for a student who has a worldview in accordance with the worldview taken for granted in science class.

In the same way, interest in the subjects is also often mentioned as a factor when trying to understand students' choices. Interest and worldview are also in some cases related. Cobern states that "*attitude and interest have cognitive roots, and thus are shaped by world view presuppositions*" (Cobern 1991). Perhaps one does not feel interested in the subject if it does not feel meaningful. On the other hand you can be interested even though you yourself do not share the view or way of reasoning. This is valid for Olivia who is interested in the conclusions of science, even though she doesn't necessarily share all views. Also Karolina can feel that science to some extent can be interesting to learn about, but she makes clear that the whole way of reasoning that she associates with science is alien to her. Because of that it does not become meaningful to engage in science studies in the same way as it is for Olivia. One difference between the two students is that the differences between Olivia's worldview and the worldview she associates with science is about specific views linked to her religious worldview, as for example a belief in a god that can influence the world. Opposite to Karolina she has no problems with the way one use to get new knowledge in science.

This difference between Olivia on the one hand and Camilla, Karolina and Hedda on the other hand put forward a questions about whether it perhaps is even harder for students with an alternative view of how knowledge can be gained and what kind of knowledge can be gained, than for students with a traditional religious worldview to identify themselves with science. That is if you yourself do not view the universe as comprehensible, or if you are sceptical against logical reasoning, or if you do not believe that the best way to get knowledge is to begin with parts adding them together afterwards—can you then find science worthwhile?

If you in addition to this associate science with scientistic views (Poole 1998) like "*Everything has or will have a scientific explanation*", "*Only science can tell us what is really true about the world*" and "*The scientific view of existence describes completely the*

reality that exists", but you yourself believe that there are more to reality than the things and phenomena that science could describe and explain—what happens then? Does science become a project that from the beginning is foredoomed to failure, and a project associated with some kind of hubris?

Those are questions that have to be dealt with, because Camilla, Hedda and Karolina are not unique in their views. Instead probably many students are sceptical against different aspects like those that are often, by the students, associated with science. Knowledge that we as humans can reach are for those youths partly of another kind than scientific knowledge described by models and laws. Sjödin (2002) has shown that rather few youths in Sweden view science as the only way to reach knowledge about the world. In his study only few youths agree with statements like "*Science is the only way we have to get real knowledge about the existence*" and "*The scientific view of existence describes completely the reality that exists*".[5] Also Reiss (2009) states that many students view the world in ways that to a great extent differ from the way school science presents it, and that this has to be dealt with if students are to engage with science, and learn science in meaningful ways.

Future research has to focus on worldview as one factor when trying to understand students' relations to science. This study indicates that students with worldviews different from the ones they associate with science tend to exclude themselves from upper secondary science programmes in Sweden. More studies on this in Sweden and in other countries would be valuable. We have seen that among students with high ability for science religious worldviews are more common among those who study other programmes than among students at the science/technology programme (Lindahl and Hansson 2009), but we have also seen that for some students the problems are also about not sharing the "project of science". How this could be dealt with in school and how we could reach those students is today an open question. Matthews (2009b) argues that it is important that students can recognise different options, and then make up their own mind. Probably a way forward then is through, in science class, problematise the kind of worldviews that are associated with science, for example through showing examples of science researchers with different kinds of worldviews. The Swedish science curriculum, as many countries curricula (Matthews 2009a) makes it possible to explicitly discuss science and worldview.

Matthews (2009a) describes how "science presupposes at least methodological naturalism", but that there are also advocates of "ontological naturalism" and "materialism" which is stricter versions which are harder to combine with for example religious views. An approach where this is discussed in science class would have the aim of students understanding that there are not a single "science worldview", but instead many different worldviews compatible with science (Cobern 2000b). This approach should include an explicit discussion in the classroom about what worldview presuppositions that science by necessity builds on (Cobern 2000b; Poole 1998; Hansson and Redfors 2007a, b). We believe that starting discussions about worldview with a discussion of presuppositions are a concrete and straight forward way to do it (see Hansson and Redfors 2007b for an example of how this can be done). The importance of presuppositions is supported by Gauch JR (2009) who writes.

> "As the discussion of science, worldviews, and education continues, presuppositions will be enormous influential." (p. 691)

[5] Translations from Swedish by the authors.

Discussing this in a cross-cultural way in the science classroom would make it possible for more students to engage in science—also students not sharing those presuppositions themselves. There is a need for more research on how this can be done, if it would be possible to in the future reach a science education that really is for all students.

Appendix A

Table 1 Statements used in the questionnaire about Nonself (The universe). The figures show the order of the statements in the questionnaire

Necessary for science (science builds upon these)
If you want to understand the whole universe, the best way is to understand every phenomenon separately (23)
Religious statements
Traditional religious statements
A god or a supreme power exists (3)
The universe is planned and has a purpose. It is not a coincidence that it looks the way it does (6)
In some way or other we will live on, even after our death (8)
A god or a supreme power can influence the development of the universe (12)
A god or a supreme power exists can intervene here on earth, for example, through miracles or wondrous events (15)
Humans have a soul (22)
Illness that medical doctors cannot cure can sometimes be cured by healing rituals, praying, or other special rites (28)
A god or a supreme power created the universe (29)
New religious statements
Telepathy between two persons can sometimes be possible (1)
Through meditation one can reach spiritual realities normally hidden from humans (2)
Logical thinking does not put us in contact with life's deeper secrets (4)
Some people have the capability to know in advance what will happen in the future (10)
Some type of cosmic power or energy connects humans with the universe (11)
Modern physics and Eastern Mysticism reach the same conclusions, but in different ways (13)
The universe is an interconnected whole that can resemble consciousness or a thought (17)
Certain stones and crystals can posses powers and energies which give strength to those whom carry them (19)
A person's life is influenced by the alignment of the stars and planets at the time she was born (20)
We have lost the wisdom that existed in old cultures (24)
Ghosts exist, for example in some old houses (25)
Everything possesses cosmic energy and is therefore interconnected (27)
Through hypnosis it is possible to remember earlier lives (30)
Naturalistic statements
Everything has or will have a scientific explanation (5)
Love is solely chemical reactions (7)
The scientific view of existence describes completely the reality that exists (9)
The universe came to be without a reason—by chance (14)
Only science can tell us what is really true about the world (16)

Table 1 continued

Humans are nothing but atoms and chemical processes (18)
One should only believe in things that have been proven (21)
The universe looks the way it does today solely because of chance and the laws of nature (26)

Appendix B

Table 2 Statements used in the interviews about Nonself (The universe). The figures show the order of the statements in the interview

Necessary for science (science builds upon these)
The physical laws that are valid here are valid also in every other place in the universe (3)
The physical laws have always been valid, that is they were valid also long way back in the history of the universe (6)
There are patterns/order in the universe that wholly or partially can be discovered and understood by humans (8)
The universe is incomprehensible for humans (11) [science presupposes that it is comprehensible, at least to some extent]
If you want to understand the whole universe, the best way is to try to understand every phenomenon separately (21)
Religious statements
Traditional religious statements
A god or a supreme power exists (4)
A god or a supreme power exists can intervene here on earth, for example, through miracles or wondrous events (7)
A god or a supreme power created the universe (10)
The universe has a meaning or purpose (12)
The universe is planned and has a purpose. It is not a coincidence that it looks the way it does (5)
A god or a supreme power can influence the development of the universe (14)
New religious statements
A person's life is influenced by the alignment of the stars and planets at the time she was born (15)
Some type of cosmic power or energy connects humans with the universe (17)
Everything possesses cosmic energy and is therefore interconnected (19)
Logical thinking does not put us in contact with life's deeper secrets (22)
The universe is an interconnected whole that can resemble consciousness or a thought (23)
Naturalistic statements
The universe came to be without a reason—by chance (1)
The universe looks the way it does today solely because of chance and the laws of nature (18)
The only thing that exists is the material world (20)
Everything has or will have a scientific explanation (2)
Only science can tell us what is really true about the world (13)
The scientific view of existence describes completely the reality that exists (16)

Appendix C

Table 3 Camilla's answers in questionnaire and card sorting activity during the interview (The order of statements in the interview (I) and questionnaire (Q) is indicated)

Statement	Questionnaire		Interview	
	Own view	View of science	Own view	View of science
Necessary for science				
The physical laws that are valid here are valid also in every other place in the universe (I:3)			Disagr.	Supports
The physical laws have always been valid, that is they were valid also long way back in the history of the universe (I:6)			Agree	Supports
There are patterns/order in the universe that wholly or partially can be discovered and understood by humans (I:8)			Agree	Supports
The universe is incomprehensible for humans (I:11) [science presupposes the opposite]			Agree	Contrad.
If you want to understand the whole universe, the best way is to try to understand every phenomena separately (I:21; Q: 23)	Agree	Supports	Disagr.	Supports
Trad. religious statements				
A god or a supreme power exists (I:4; Q: 3))	Agree	Contrad.	Agree	Contrad.
A god or a supreme power exists and can intervene here on earth, for example trough miracles or wondrous events (I:7; Q:15)	Agree	Contrad.	Agree	Contrad.
A god or a supreme power created the universe (I:10; Q:29)	Agree	Contrad.	Disagr.	Contrad.
The universe has a meaning or purpose (I: 12)			Agree	Supports
The universe is planned and has a purpose. It is not a coincidence that it looks the way it does (I:5; Q:6)	Agree	Supports	Agree	Supports
A god or a supreme power can influence the development of the universe (I:14; Q:12)	Agree	Contrad.	Agree	Contrad.
Humans have a soul (Q:22)	Agree	Contrad.		
In some way or orther we will live on, even after our death (Q:8)	Agree	Contrad.		
Illness that medical doctors cannot cure can sometimes be cured by healing rituals, praying, or other special rites (Q:28)	Agree	Contrad.		
New religious statements				
A person's life is influenced by the alignment of the stars and planets at the time she was born (I:15; Q:20)	Agree	Neith. nor	Agree	Supports
Some type of cosmic power or energy connects humans with the universe (I:17; Q:11)	Agree	Contrad.	Agree	Supports
Everything possesses cosmic energy and is therefore interconnected (I:19; Q:27)	Agree	Contrad.	Don't know	Supports
Logical thinking does not put us in contact with life's deeper secrets (I:22; Q:4)	Agree	Neith. nor	Agree	Contrad.
The universe is an interconnected whole that can resemble consciousness or a thought (I:23; Q:17)	Agree	Contrad.	Don't know	Don't know

Table 3 continued

Statement	Questionnaire		Interview	
	Own view	View of science	Own view	View of science
Telepathy between two persons can sometimes be possible (Q:1)	Agree	Contrad.		
Trough mediation one can reach spiritual realities normally hidden from humans (Q:2)	Agree	Contrad.		
Some people have the capability to know in advance what will happen in the future (Q:10)	Agree	Contrad.		
Modern physics and Eastern Mysticism reach the same conclusions, but in different ways (Q:13)	Agree	Contrad.		
Certain stones and crystals can posses powers and energies which give strength to those whom carry them (Q:19)	Agree	Contrad.		
We have lost the wisdom that existed in old cultures (Q:24)	Agree	Neith. nor		
Ghosts exist, for example in some old houses (Q:25)	Agree	Contrad.		
Through hypnosis it is possible to remember earlier lives (Q:30)	Agree	Contrad.		
Naturalistic statements				
Everything has or will have a scientific explanation (I:2; Q:5)	Disagr.	Supports	Disagr.	Supports
Only science can tell us what is really true about the world (I:13; Q:16)	Disagr.	Supports	Disagr.	Contrad.
The scientific view of existence describes completely the reality that exists (I:16; Q:9)	Disagr.	Supports	Disagr.	Supports
One should only believe in things that have been proven (Q:21)	Disagr.	Supports		
The only thing that exists is the material world (I:20)			Disagr.	Supports
Love is solely chemical reactions (Q:7)	No answer	Supports		
Humans are nothing but atoms and chemical processes (Q:18)	Disagr.	Supports		
The universe came to be without a reason—by chance (I:1; Q:14)	Disagr.	Contrad.	Disagr.	Neither nor
The universe looks the way it does today solely because of chance and the laws of nature (I:18; Q: 26)	Disagr.	Supports	Disagr.	Supports

References

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27*, 1–52.

Aikenhead G. S. (2006). *Science education for everyday life. Evidence-based practice*. Teachers College Press.

Alters, B. J. (1997). Whose nature of science? *Journal of Research in Science Teaching, 34*(1), 39–55.

Arlebrand, Hermansson and Wallin (2003) *Ny tid ny tro?: Nyandliga rörelser och riktningar i dagens samhälle*. [New time new beliefs?: New religious movements and directions in society of today] Gleerup, Malmö.

Baker, D., & Taylor, P. C. S. (1995). The effect of culture on the learning of science in non-western countries: The results of an integrated research review. *International Journal of Science Education, 17*(6), 695–704.

Brewer, W. F., & Chinn, C. A. (1991). Entrenched beliefs, inconsistent information, and knowledge change. In L. Birnbaum (Ed.), *The international conference of the learning sciences: Proceedings of the 1991 Conference Charlottesville, Virginia: Association for the Advancement of Computing in Education* (pp. 67–73).

Brickhouse, N. W. (2001). Embodying science: A feminist perspective on learning. *Journal of Research in Science Teaching, 38*(3), 282–295.

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal for Research in Science Teaching, 37*(5), 421–458.

Cobern, W. W. (1991). World *view theory and science education research*. NARST Monograph No. 3. Manhattan, KS: National Association for Research in Science Teaching.

Cobern, W. W. (1993). College Students' conceptualizations of nature: An interpretive world view analysis. *Journal of Research in Science Teaching, 30*(8), 935–951.

Cobern, W. W. (1996). Worldview theory and conceptual change in science education. *Science Education, 80*(5), 579–610.

Cobern, W. W. (2000a). *Everyday thoughts about nature*. Dordrecht: Kluwer Academic Publishers.

Cobern, W. W. (2000b). The nature of science and the role of knowledge and belief. *Science & Education, 9*, 219–246.

Cobern, W. W., & Aikenhead, G. S. (1998). Cultural aspects of learning science. In H. J. Fraser & K. G. Tobin (Eds.), *The international handbook of science education* (pp. 39–52). Dordrecht: Kluwer.

Cobern, W. W., & Loving, C. C. (2000). Defining "Science" in a multicultural world: Implications for science education. *Science Education, 85*, 50–67.

Costa, V. B. (1995). When science is "Another World": Relationships between worlds of family, friends, school, and science. *Science Education, 79*(3), 313–333.

Dagher, Z. R., & BouJaoude, S. (1997). Scientific views and religious beliefs of college students: The case of biological evolution. *Journal of Research in Science Teaching, 34*(5), 429–445.

EU. (2004). *Europe needs more scientists*. Report by the High Level Group on Increasing Human Resources on Science and Technology in Europe from http://ec.europa.eu/research/conferences/2004/sciprof/pdf/final_en.pdf. Accessed 20 Feb 2009.

EU. (2005). Science and Society Portal of the European Commision. Retrieved 2009-02-20 from http://ec.europa.eu/research/conferences/2004/sciprof/pdf/final_en.pdf.

Gardner, P. L. (1975). Attitudes to science: A review. *Studies in Science Education, 2*, 1–41.

Gauch, H. G., Jr. (2009). Science, worldviews, and education. *Science & Education, 18*, 667–695.

Glennan, S. (2009). Whose science and whose religion? reflections on the relations between scientific and religious worldviews. *Science & Education, 18*, 797–812.

Hammer O. (2004). *På spaning efter helheten. NEW AGE en ny folktro?* Wahlström & Widstrand.

Hansson, L. (2007). "*Enligt fysiken eller enligt mig själv?" – Gymnasieelever, fysiken och grundantaganden om världen. ("According to physics or according to myself?" – Upper secondary students, physics, and presuppositions about the world)* (Diss., Studies in Science and Technology Education No 13), Linköping University. http://liu.diva-portal.org/smash/record.jsf?searchId=1&pid=diva2:17293.

Hansson, L., & Redfors, A. (2006a). Swedish upper secondary students' views of the origin and development of the universe. *Research in Science Education, 36*, 355–379.

Hansson, L., & Redfors, A. (2006b). Tre elever berättar om universum, gud och fysiken. *Nordina, 1/06*, 31–43.

Hansson, L., & Redfors, A. (2007a). Physics and the possibility of a religious view of the universe: Swedish upper secondary students' views. *Science & Education, 16*, 461–478.

Hansson, L., & Redfors, A. (2007b). Upper secondary students in group discussions about physics and our presuppositions of the world. *Science & Education, 16*, 1007–1025.

Härnqvist K. (1998). A *longitudinal program for studying education and career development* (Report 1998:01). Göteborg University: Department of Education and Educational Research.

Helve, H. (1991). The formation of religious attitudes and world views: A longitudinal study of young finns. *Social Compass, 38*(4), 373–392.

Jacobs, J. E., Simpkins S. D. (Eds.). (2005). *Leaks in the pipeline to math, science, and technology careers: New directions for child and adolescent development*. No. 110.

Jegede, O. J. (1995). Collateral learning and the eco-cultural paradigm in science and mathematics education in Africa. *Studies in Science Education, 25*, 97–137.

Kearney, M. (1984). *World view*. Novato, California: Chandler & Sharp Publishers, Inc.

Kilbourn, B. (1980). World views and science teaching. In: H. Munby, G. Orpwood, & T. Russell (Eds.), *Seeing curriculum in a new light. Essays from Science Education*. Toronta, Canada: OISE Press/The Ontario Institute for Studies in Education (pp. 34–43).

Kilbourn, B. (1980–1981). World views and curriculum. *Interchange*, 11(2), 1–10.

Krogh, L. B. (2005). Studying students' attitudes towards science from a cultural perspective but with a quantitative methodology: Border crossing into the physics classroom. *International Journal of Science Education, 27*(3), 281–302.

Lacey, H. (2009). The interplay of scientific activity, worldviews and value outlooks. *Science & Education, 18*, 839–860.

Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of Research in Science Teaching, 38*(3), 296–316.

Lindahl, B. (2003). *Lust att lära naturvetenskap och teknik? En longitudinell studie om vägen till gymnasiet. (Pupils' responses to school science and technology? A longitudinal study of pathways to upper secondary school.)* (Diss., Göteborg studies in educational sciences 196), Göteborg: Acta Universitatis Gothoburgensis English summary on http://gupea.ub.gu.se/dspace/handle/2077/9599.

Lindahl, B. (2007). A longitudinal study of students' attitudes towards science and choice of career. In *Proceedings (CD) from NARST annual conference 2007*, New Orleans, 15th–18th April.

Lindahl, B., & Hansson, L. (2009). Students' presuppositions of what the world is like and their interest in choosing a science. In *Proceedings (CD) from NARST annual conference 2009*, Los Angeles, 17th–21th April.

Lyons, T. (2006). Different countries same science classes: Students' experiences of school science in their own words. *International Journal of Science Education, 28*(6), 591–613.

Matthews, M. R. (2009a). Science, worldviews and education: An introduction. *Science & Education, 18*, 641–666.

Matthews, M. R. (2009b). Teaching the philosophical and worldview components of science. *Science & Education, 18*, 697–728.

National Agency for Education. (2000). The Swedish education system. Available from http://skolnet.skolverket.se/polopoly/utbsys-eng/Accessed 11 August 2009.

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections. A report to the Nuffield foundation*. Available from http://www.nuffieldfoundation.org/fileLibrary/pdf/Sci_Ed_in_Europe_Report_Final.pdf. Accessed 10 Jun 2009.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049–1079.

Phelan, P., Davidson, A. L., & Cao, H. T. (1991). Students' multiple worlds: Negotiating the boundaries of family, peer, and school cultures. *Anthropology & Education Quarterly, 22*, 224–250.

Poole, M. W. (1998). Science and science education: A judeo-christian perspective'. In W. W. Cobern (Ed.), *Socio-cultural perspectives on science education. An international dialogue* (pp. 181–201). Dordrecht: Kluwer Academic Publishers.

Proper, H., Wideen, M. F., & Ivany, G. (1988). World view projected by science teachers: A study of classroom dialogue. *Science Education, 72*(5), 547–560.

Reiss, M. (2009). Imagining the world: The significance of religious worldviews for science education. *Science & Education, 18*, 783–796.

Roberts, D. A. (1998). Analysing school science courses: The concept of companion meaning. In D. A. Roberts & L. Östman (Eds.), *Problems of meaning in science curriculum* (pp. 5–12). New York: Teacher College Press.

Säther, J. (2003). The concept of ideology in analysis of fundamental questions in science education. A rewiew with selected examples from norwegian curricula and textbooks. *Science & Education, 12*, 237–260.

Schibeci, R. A. (1984). Attitudes to science: An update. *Studies in Science Education, 11*, 26–59.

Schreiner, C. (2006). *EXPLORING A ROSE-GARDEN Norwegian youth's orientations towards science—seen as signs of late modern identities* Department of Teacher Education and School Development Faculty of Education University of Oslo.

Science & Education. (2009). *18*(6–7). *Special issue science, worldviews and education* (M. R. Matthews (Ed.)).

Sjøberg, S., & Schreiner, C. (2005). Naturfag og teknologi i skole og samfunn: Interesse of rekruttering. [Science and technology in school and society. Interest in recruitment.] *Utdanning.*

Sjödin, U. (1995). *En skola—flera världar. Värderingar hos elever och lärare i religionskunskap i gymnasieskolan*. [One school—many worlds. Students' and teachers' values in religious education in upper secondary school] Bokförlaget Plus Ultra, Helsingborg.

Sjödin, U. (2001). *Mer mellan himmel och jord? En studie av den beprövade erfarenhetens ställning bland svenska ungdomar* [More under the sun? A study of learned experiences among Swedish youth] Verbum, Stockholm.

Sjödin, U. (2002). Övertron på övertron och den sekulariserade ungdomens religiositet [Superstition on superstion and the religiousness of the secularized youth] In O. Franck (Ed.), *Mellan vidskepelse och vetenskap. Att tro, att tvivla—och att veta.* [Between superstition and science. To believe, to doubt—and to know.] Föreningen lärare i religionskunskap. Årsbok 2002, Årg 34.

Stenmark, M. (2001). *Scientism: Science, ethics and religion*. Aldershot: Ashgate Science and Religion Series.

Stenmark, M. (2004). *How to relate science and religion: A multidimensional model*. Grand Rapids, USA: Eerdmans.

Trusted, J. (1991). *Physics and metaphysics: Theories of space and time*. London and New York: Routledge.

Worthley, J. S. (1992). Is science persistence a matter of values? *Psychology of Women Quarterly, 16*, 57–68.