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RESEARCH REPORT

'To trust or not to trust, ...'-pupils' ways of judging information encountered in a socio-scientific issue

Stein Dankert Kolstø, Department of Applied Education, University of Bergen, Norway

This article reports from a qualitative study of how 16-year-old Norwegian pupils dealt with a socio-scientific issue. The pupils were interviewed on aspects of their decision-making concerning a local version of the well-known controversial issue: whether or not power transmission lines increase the risk for childhood leukaemia. The part of the study reported here has focused on their views on the trustworthiness of knowledge claims, arguments and opinions given to them prior to interview.

It was found that many aspects of trustworthiness were experienced as problematic by the pupils. Using inductive analysis, four main kinds of 'resolution strategies' were identified that were used by the pupils to decide who and what to trust: 1) Acceptance of knowledge claim, 2) Evaluation of statements using 'reliability indicators' and through explicitly 'thinking for themselves', 3) Acceptance of researchers or other sources of information as authoritative, 4) Evaluation of sources of information in terms of 'interests', 'neutrality' or 'competence'. Some pupils used all these strategies, others used only one or two. The pupils' evaluations were nuanced and based partly on empirical evidence, but mostly on rather superficial contextual information. It is argued that some of the resolution strategies imply that autonomous evaluations were made. One main conclusion is that knowledge of different sources of scientific information needs to be more emphasized in science education for citizenship.

Introduction

When adolescents deal with controversial socio-scientific issues, how do they sort out what information, and what sources of information, to trust? Their task is not an easy one. This is due to the many opinions on such issues and the fact that the science involved is normally frontier science for which consensus has not yet been reached.

The ability of citizens to deal fruitfully with socio-scientific issues has been recognized as an important goal for science education (Zoller 1982, AAAS 1989, Jenkins 1994, Driver *et al.* 1996, Millar 1996, NRC 1996, Osborne 1997). It has also been argued that thoughtful decision-making on such issues is important in democratic societies (Aikenhead 1985, Fullinwider 1987, Sjøberg 1997). This article reports a study of how pupils in grade 10 dealt with the controversial issue of power transmission lines and the claim that these might cause childhood leukaemia. Knowledge of how pupils deal with such issues is of relevance to the discussion of public understanding of science, as it provides information on lay people's use of, and need of, science. It is also important when designing curricula and teaching models aiming at science for citizenship.

In this study a selection of 22 pupils from four science classes were interviewed in depth on different aspects of their decision-making on the chosen issue. The part of the study reported here focused on how the pupils judged the trustworthiness of the information encountered, in order to arrive at a personal opinion.

The question of trust is an important one. Making a thoughtful decision on a socio-scientific issue is not only a question of knowledge and a broad decision-base. One is also necessarily confronted with the question of trustworthiness. As reported from the study by Layton *et al.* (1993):

> Interaction of the adults with science was rarely, if ever, a narrowly cognitive one. For example, importance was given to the source of the science, and particularly to the extent to which it could be judged trustworthy and reflective of understanding of their situation. (p. 130)

In addition to the scientific knowledge offered, one usually also has to deal with the issue of the trustworthiness of knowledge claims from other actors engaged in an issue.

Related research

Within the field of risk communication there have already been some studies on lay peoples' evaluations of the trustworthiness of information on controversial issues. In these studies the focus has been on which general sources people trust for information on undefined risk issues (Jungermann *et al*, 1996, Peters *et al.* 1997), and on the characteristics of trusted sources (Frewer *et al.* 1996, Peters *et al.* 1997). The study reported here, however, focuses on pupils' ways of dealing with *one specific issue*, making the research context more similar to a real life situation. In addition, this study had a broader aim as it also tried to identify *problems encountered* by the pupils when trying to establish a firm decision-making base. It also included the pupils' evaluations of the *knowledge claims* themselves and not only of their sources.

Within science education there have been some studies focusing on pupils' ways of dealing with information in media reports of scientific research (Norris and Phillips 1994, Korpan *et al.* 1997, Phillips and Norris 1999). Korpan *et al.* (1997) focuses on types of requests for further information made by first year university students after reading a scientific news brief. The students were asked to judge the plausibility of conclusions presented. The study thus provides insights into students' criteria

for judging trustworthiness of scientific knowledge claims, but their research did not focus on socio-scientific issues.

Ratcliffe (1999), however, focuses on scientific research with a social relevance. She explored the ability of secondary school pupils to evaluate evidence provided in media reports of contemporary science. They were asked to judge whether a certain claim could be regarded as proved. The results showed that some pupils and students accepted some information without evaluation, while others pointed to insufficient evidence or to the possible role of scientists' integrity or beliefs. The study also identified reasons given by pupils and students when disbelieving data.

The research of Norris and Phillips (1994) and Phillips and Norris (1999) considered how students' evaluations of certainty of claims were altered by reading popular reports of science on the subject. They found that students tended to interpret statements in the popular reports as less uncertain, and thus with a higher 'truth value', than signalled by the researchers involved. They also found that, in general, students readily accepted the claims made in the reports, but also that a significant number of students critically evaluated a report.

A study by Gaskell showed how pupils used the legitimacy of spokespersons to judge arguments when engaged in socio-scientific issues. Other studies have focused more on pupils' use of scientific knowledge when analysing socio-scientific issues, but without focusing on the students' views on the *trustworthiness* of different kinds of information (Fleming 1986, Solomon 1992).

There have been a number of qualitative studies on a variety of social groups involved in different issues with a science dimension (e.g. Layton *et al.* 1993, Irwin 1995, Irwin and Wynne 1996). As concluded by Jenkins (1997) and Wynne (1991), these studies have given valuable insights into the relationship of lay citizens to science. In this research the focus was on adults, and on situations where the issue somehow was a part of their everyday life. When focusing on democratic partici-pation, however, it is important to gain insights into how pupils as lay people deal with socio-scientific issues presented and discussed in the *media*. The study reported here therefore focuses on how 15-16 year old pupils participating in a general science course dealt with a specific socio-scientific issue covered by local media. For most of the pupils in Norway this course in general science is the last science course they take. Thus the findings may also be used to evaluate the citizenship dimension of the compulsory science education in Norway.

Power transmission lines and childhood leukaemia

The issue of power transmission lines was chosen since it was a topical controversial issue covered by local Norwegian newspapers and it did indeed have a science dimension. The topicality of the issue arose when a local power company, Bergenhalvoens kommunale kraftselskap (BKK), applied for the upgrading of an existing power transmission line from ISOkV to 300 kV. A debate ensued in the newspapers, first concerning the upgrading of this existing line, and later concerning the construction of a new 300 kV line within the same community. Both the line to be upgraded and the new one to be constructed passed in part through inhabited areas.

Results from scientific research were at the heart of this issue. The issue was triggered by research that concluded that the magnetic field emanating from power transmission lines could cause an increased risk for leukaemia (blood cancer) for children living within a certain range from the line (Harboe 1994). During the two last decades there have been several epidemiological studies focusing on the correlation between estimated exposure to magnetic fields from power transmission "nes and the occurrence of leukaemia. In Norway, the Ministry of Health and Social Affairs initiated a meta-study of the research on electromagnetic fields and Possible health effects (Harboe 1994). According to this report, the results from the epidemiological studies have differed to some degree. Some studies found a correlation between residential exposure to magnetic fields from power transmis-sion 1ines and incidence of leukaemia, while others found no correlation. Thus, when the interviews for this study were conducted, there was no consensus within the scientific community as to whether there is an increased risk or not (Tynes 1996). The science involved in this issue was therefore non-consensual frontier science, or science-in-the-making as Latour (1987) calls it.

To put a cable underground provides an alternative to overhead lines. If underground cables are chosen, the magnetic field is supposedly somewhat increased at small distances from the lines at surface level (due to the shorter vertical distance to underground cables compared to overhead lines). On the other hand, the field strength decreases considerably faster with distance for underground cables than for overhead ones (BKK 1995). The positions on the issue have tended to be somewhat polarised; pro or against underground construction. According to media reports the power company claimed that underground cables cost more,

and may imply lower stability of delivery. The power company argued against underground cables, and were reported to state that the claimed risk had not been 'proven' (Radahl 1995). Media reports also indicated that residents living close to the lines, on the other hand, demanded underground cables, or a new trajectory for the lines to be constructed. It was also reported that the lay opinion on the issue was to some extent mixed, but apparently with most people in favour of underground cables.

Research question and methodology

The aim of this study was to gain insights into pupils' ways of deciding upon the trustworthiness of information and knowledge claims when engaged in a socio-scientific issue. The concept 'trustworthiness' here denotes the extent to which information and knowledge claims were seen as sufficiently reliable for inclusion in the pupils' decision-making bases. The study thus sought to identify the different ways in which the pupils judged information and knowledge claims, for possible inclusion in their decision-making base on an issue. It was decided to use a qualitative approach, as the research question was exploratory and implied a focus on pupils' ideas and idea categorizations.

Twenty-two pupils from four different schools and science classes were interviewed individually about their decision-making on the chosen issue. The interviews were semi-structured and included several written-out questions. The semi-structured design ensured that all respondents were confronted with a set of core questions. This 'common area' across the different interviews was thought to be important, to increase the reliability of the study. The interviewer's use of open questions, of probes and of follow-up questions provided an opportunity for the interviewee to introduce and elaborate upon unexpected themes and ideas, and was used to strengthened the explorative character of the study.

Several issues were in focus throughout the interviews, each of which lasted from 40 to 60 minutes. A main issue was the respondents' explanation of their opinion on the issue: what were their main arguments?; what knowledge did they regard as relevant?; what would they like to know more about?; and what were their personal opinions? A second main issue was the trustworthiness of knowledge claims and different sources of information encountered in the preparatory phase: whom did they prefer to listen to, and why?; were the risk proved?; what would it take to convince them of a risk to be, or not to be, present?; what did they think about the local residents' and the power company's views on the different research results?; how could it be that different researchers seemed to present different findings?; was subject matter knowledge about electricity relevant?; and, if so, why was this scientific knowledge trustworthy?

Before selecting pupils for interviewing, a preparatory phase was arranged in the four science classes. The aim of this phase was to ensure that all pupils had some knowledge of the issue. It was also hoped that this information would elicit the pupils' thoughts and emotions concerning actors and information involved in the issue. During the two science lessons the pupils were first shown transparencies with copies of newspaper articles and some research reports and official documents. Thereafter, focused group-discussions on the issue were arranged. In preparing the study, both the classroom activities and the interview-guide were piloted, and adjustments made.

The interviewees, schools and teachers were selected using 'purposeful sampling' (Merriam 1988, Patton 1991). Two selection criteria were used, in addition to grade and science course: *engagement* and *variation*. Engagement was a criterion because only engaged pupils would get their ideas and emotions into active play, and thus be able to explain their thinking. Variation in pupils' background, opinions, level of ambivalence, ways of expression, and sex was important to increase the external validity of the study (Eneroth 1984). Due to taping and transcribing of the group-discussions, it was possible to apply both these criteria when selecting interviewees.

All pupils asked were willing to be interviewed, except from one very shy girl. Many pupils seemed to hope for selection. It was my impression that the pupils were curious and hoped that I as a researcher would be interested in just *their* thoughts. In advance the pupils were told that they would be asked questions that did not have any specific 'right' or 'wrong' answers, but that I as a researcher was interested in *their* thoughts and ideas. They were also told that the interview would centre around their views on different aspects of the socio-scientific issue they had been discussing.

The interviews were conducted within school hours in a small room at the different interviewees' schools. All pupils talked in an open and frank manner in the interviews, indicating that they did not try to adjust to any perceived expectations or demands.

The use of the preparatory phase with a teaching sequence and group-discussions was regarded as an important step to increase the validity of the findings. This made it possible to talk with the respondents within a common and concrete context, as the pupils then all knew that the interviewer had joined the teaching sequence, and also that I, the interviewer, knew about the group discussions. Building on this shared context, the phrasing of the questions posed to the student could be made *less abstract*. This strategy was used to prevent misunderstandings and thereby increased the internal validity of the findings (Merriam

1988).

Inductive analyses (Patton 1991) of fully transcribed interviews were used in this study. This implies that it was sought not to impose pre-existing expectations on the phenomenon, and that there were no predefined categories to fit the data into. The starting point was a phenomenon, decisions on the trustworthiness of information and knowledge claims, and a specific issue.

The analysis of the data proceeded through two distinctive phases. In both phases, descriptive categories were developed through alternation between varying degrees of 'discovery mode' and 'verification mode' (Guba 1978). In a preliminary phase, views, opinions and interpretations, explicitly or implicitly related to the trustworthiness of information and its sources, were identified. All the pupils were found to express problems and uncertainty when trying to sort out who to trust and what to believe. But on the other hand they also made decisions and articulated criteria for evaluating information and its sources for trustworthiness. This emerging pattern was developed into an analytical tool for the subsequent main phase of the analysis. The tool consisted of a categorisation of the pupils' views: a) as implying trust to be unproblematic, b) as problems expressed, or c) as strategies to deal with the identified problems.

From inspection of transcribed interviews, more specific categories describing the pupils' ways of evaluating and judging trustworthiness were developed. Emerging categories were inspected for applicability and adjusted for every fourth to sixth interview analysed. Before the end of the process the need for further adjustment of the categories faded, indicating that the categories were exhaustive in relation to the phenomenon studied and thus hold external validity.

Results: 'To trust or not to trust, that is the question'

The analysis produced five main categories to describe the pupils' views and ideas, interpretations and problems concerning the issue of trustworthiness. One of these was conceptualized as 'problems encountered'. Its sub-categories denote the different problems the pupils were found to encounter when trying to explain, defend or reach a decision on the chosen issue during the interviews.

The four other main categories describe different 'resolution strategies' found to be used by the pupils when trying to get a firm decision-base. The concept 'resolution strategy' was chosen since the pupils' different ways of dealing with the issue of trust frequently were expressed as solutions to problems encountered. The phrase 'resolution strategy' was also chosen because all but one pupil arrived at a personal decision on the issue on underground versus overhead lines, in spite of the problems encountered. This implies that the pupils managed to make decisions, at least implicitly, regarding the trustworthiness of knowledge claims, information and arguments. The four 'resolution strategies' identified were 'the acceptance of knowledge claims', 'the acceptance of authority', 'the evaluation of statements' and 'the evaluation of authorities'.

Reaction → Focus ?	ACCEPTANCE	EVALUATION
STATEMENTS (Content-focused)	1. 'Acceptance of knowledge claims'	2. 'Evaluation of statements' *2a. 'Evaluation of knowledge claims'* *2b. 'Autonomous evaluation'*
AUTHORITIES (Sources of knowledge and information)	3. 'Acceptance of authority' *3a. 'Researcher confidence'* *3b. 'Actor specific confidence"*	4. 'Evaluation of authority' *4a. 'Analysis of opinion on risk'* *4b. 'Analysis of interest'* *4c. 'Analysis of neutrality'* *4d. 'Analysis of competence'*

Figure 1. 'Resolution strategies' found to be used by the pupils when trying to get a reliable knowledge base for their decisions. Main categories are underlined, and sub-categories are written in italics.

These categories indicate that the pupils' resolution strategies were found to be used with *statements and knowledge claims,* or with the sources, or *authorities,* offering knowledge and arguments. The resolution strategies were also found to involve either *acceptance* of a statement or an authority, or *evaluation* of a statement or an authority. Sources of knowledge claims are denoted here as *authorities* because the pupils often seemed *not* to look at the *content* of the knowledge claims: instead they evaluated the sources of the claims. If a source is accepted as offering trustworthy information without an evaluation of the content of its knowledge claims, the pupil implicitly leaves the evaluation of the validity and reliability of these knowledge claims to the source. The source is thus treated as a potential *authority* when it comes to the validity and reliability of these knowledge claims.

An overview of identified categories is given in figure 1. These categories do not describe single pupils or differences between them, but rather the range of different resolution strategies found to be

used. Most pupils applied several of these.

'Problems encountered'

> Unni: No, I am not convinced by that one [the Norwegian study finding no increased risk], but I am not really sure it is possible to convince me that there is more cases of cancer either. I am just not completely sure, but I wouldn't exclude the possibility.

Three different kinds of problems were identified:

1. The researchers did not seem to agree on the risk level.
2. The research might not have been of satisfactory quality.
3. Some researchers might have been biased.

All these problems concern the research and the researchers involved, and they also reflect the pupils' interpretations of perceived information. These issues were interpreted as problems since they concerned the trustworthiness of knowledge claims discussed by the pupils, and since the pupils at the same time expressed doubt and uncertainty. Thus these issues made it more difficult for the pupils to get a decision-base, and thus to arrive at a personal opinion on the issue.

Not all pupils were found to experience all three kinds of problems, but most of them articulated at least two of them. In addition, about half the pupils stated in more general terms that it was difficult to know what information to trust and which sources to believe. A few pupils also mentioned journalists' presentations and all the diverging opinions on the issue as problematic.

Concerning the first type of problem, *all* pupils were found to have the perception that the researchers disagreed, or that the researcher did not know the risk. The following quotation illustrates this first kind of problem:

> I: Are there other things ... you would like to know more about?
> Tore: Yes, what the truth really is. For there are some who say it is not dangerous with this radiation, and others who say it is dangerous. ... This makes it very difficult.

The second kind of problem was expressed by more than half of the pupils, and is illustrated by the following quotations:

> I: Do you have any idea as to how the researchers undertook their inquiries?
> Trond: It doesn't seem like they have measured the radiation, but only looking up cases instead,—they are looking for how many have got leukaemia, in a way.

> I: Do you have any idea as to how the researchers undertook their inquiries?
> Mats: No, I don't have any idea.... But the inquiries do have some uncertainties. There might be several [children] who have got leukaemia for other reasons than power transmission lines.

These pupils seem to express some doubt on whether the research on the topic had been conducted by competent researchers. Frustrations and suspicions like these presumably stem from the pupils' impression that the researchers disagreed and that they did not have an answer to the risk question. This implies the argument to be that 'they don't know, because they don't know *how'*. This reaction has also been suggested by Collins and Shapin (1986) as a natural response when pupils have no knowledge of the characteristics of frontier science.

About half of the pupils made statements indicating that the third kind of problem identified, the possible influence of researchers' interests and personal pre-opinions on findings or statements, sometimes made it more difficult to know who they could trust:

> I: How can it be that the researchers look differently at the health risk you think?
> Mari: It is probably because they have made their own opinions. They might have different backgrounds and have come across different information. Maybe they have made up their mind in advance, and then found that their opinion is right and taken that as a starting point... .

> I: So you are not completely sure the researchers manage to be neutral when they perform a study?
> Mari: Some of them might of course be, but I doubt that all of them are.

> I: How do you think the BKK looks at those research results that indicate power transmission lines to involve an increased risk for leukaemia among children?
> Rune: Probably the same way as I do, that the health risk, in fact, is very small. When it comes to findings where there is a dispute as to whether something is provable or not, it is usual that those who have managed to show it have done their utmost to prove it. [...] Their attitude has been that 'I want to prove my standpoint'.

The pupils were not found to regard the possible interests of the power company, or the local residents, as problematic. When these actors' interests were talked about, the pupils typically concluded that they were not to be trusted, but these decisions were made without any indication of the decision to have been problematic. A possible hypothesis here is that the potential pre-opinions, subjectivity, and interests, of researchers are harder to cope with, because the researchers constitute a heterogeneous group. The pupils' problem seem to be how to know which researchers are biased and which are not.

One striking feature of the problems identified, is that they all seem to be related to the pupils' perception of the researchers as *disagreeing*. In the teaching sequence the interviewed pupils had been shown several transparencies where findings from studies were referred. In a newspaper article shown on a transparency, an expert was cited:

> We can anticipate one more case every third year among children living within 50 meters from a power transmission line.

Another transparency shown, this time from a research report, stated that in a newly finished Norwegian study no increased risk had been found. Such statements make the pupils' interpretations understandable.

Having identified different aspects of the problems expressed by different pupils, a question naturally arises: How did the pupils deal with these problems? And, are their tools for dealing with the problems adequate? The first of these two questions will now be discussed. The second will be left for the discussion at the end of the paper.

First resolution strategy: 'acceptance of knowledge claims'

Three resolution strategies in figure 1 were used by the pupils as reactions to the 'problems encountered'. The resolution strategy 'acceptance of knowledge claims' was the exception. Views belonging to this category involved the validity of certain knowledge claims to be taken for granted and no problems with trustworthiness seemed to be experienced.

During the teaching sequence the pupils were shown a copy of some figures from a leaflet made by the power company. The figures showed the strength of the magnetic field, measured in microtesla *(μT),* at different distances both from overhead and underground lines. In addition there were figures showing the magnetic field strength at rather short distances from a razor, a microwave oven, a vacuum cleaner, and an electrically heated floor. The numbers assigned to these ordinary household equipment were in general higher than those associated with the power transmission lines. The magnetic field strength were shown to be considerably weaker from underground lines than from overhead lines (0,1 vs. 2,5 μT at a distance of 20 metres) except for very small distances (5 vs. 11,2 μT at zero distance at ground level).

Whether pupils were in favour of underground lines, as most of them were, or not, they *all* seemed to take for granted that the numbers presented were trustworthy. When the pupils in the interviews were asked if they had learned anything new during the two science lessons on the issue, the most frequent answer referred to the magnetic field strengths. This information given in the leaflet was often taken as a base for arguments and discussions.

One pupil very clearly stated a distrust of the power company's safety assurance because of their economic interests. But even he expressed trust in the figures indicating the magnetic field strength:

> I: The teacher showed you a copy from the brochure. My impression was that you used it [in the group discussion], and you also mentioned it. What about that, was that easier to trust?
> Nils: If they put their facts in a leaflet and immediately had said 'no, this is wrong', they would have lost all the trustworthiness they had, so I doubt that [information] is wrong.

This pupil was the only one to mention interest as an issue in connection with the numbers presented on the magnetic field strength. The sources of information were clearly marked on all transparencies.

Several other 'facts' presented by the power company were also taken for granted to be true. No pupils questioned the company's claim that underground lines would cost considerably more. No pupils questioned that error detection and repair and thereby stability of deliverance would be more difficult for the power company. No pupils questioned the information given by the teacher, and implicitly given in the company's leaflet, that underground lines constituted a possible alternative which would emit less radiation.

According to several newspaper articles, local residents with small children said they felt insecure and anxious because of the power lines. This information was very important to many pupils' decisions, but was still never questioned. This claim *could* be seen in relation to another claimed consequence of the power transmission lines not questioned by the pupils: decreasing house prices in areas close to the lines. To protect one's children from risking leukaemia *could* have been seen by the interviewees as a tactical argument while the real reason was to prevent declining house prices, but it was not.

These findings indicate that some information and some knowledge claims were not questioned at all by the pupils. And this was so even though more or less all the pupils frequently explained the evaluations and opinions on the risk held by the sources of these knowledge claims, the power company and the local residents, in terms of their interests. A plausible hypothesis here could be that the pupils trusted the information discussed in this section because they had not heard of anyone else who had questioned it. Ready acceptance of scientific knowledge claims without any evaluation was also found in both Ratcliffe's (1999)

and Phillips' and Norris' (1999) studies on students' ability to interpret media reports on scientific research.

Second resolution strategy: 'evaluation of statements'

Three of the four main resolution strategies identified were used when trying to cope with the problems experienced. One of these three resolution strategies dealt with evaluations of the content of statements. This resolution strategy was called 'evaluation of statements', and two different ways of evaluating were found. The first of these, 'evaluation of knowledge claims', focused on specific knowledge claims, and might be interpreted as the pupils' 'substitute' for evaluations based on empirical evidence. The second was conceptualized as 'autonomous evaluation', and describes some pupils' articulation of a need to evaluate the different information and opinions offered.

Resolution strategy 2a: 'evaluation of knowledge claims' using 'reliability indicators'

In the preparatory phase prior to the interviewing, several science-based knowledge claims were presented to the pupils. Critical examination of reasons supporting scientific claims is often thought of as a condition for intellectual independence, and an important goal for science education (Norris 1995). In the present study most pupils did show some interest in scientific evidence and knowledge claims, but first and foremost they wanted to know whether or not the power transmission lines were harmful. Only a few pupils said they would believe the lines to be dangerous anyhow, but they also used current research findings as arguments. However, the pupils showed very little interest in empirical evidence *underpinning* knowledge claims like the risk estimates. Most pupils used the information on the magnetic field strengths mentioned earlier in their discussions, but there was no indication of any interest in the measurements underpinning the figures presented. A few pupils expressed a positive interest in methodological aspects when asked. Some pupils also wanted more information on the economical, social or political aspects of the issue.

But does this imply use of, or interest in, evidence? One might define evidence based reasoning as having good reasons or empirical evidence (Hardwig 1985). Using this definition it can be said that many pupils used evidence as they based, or tried to base, their decision on knowledge, and thereby had good reasons. But there was no evaluation of knowledge claims based on *underpinning empirical evidence.*

Nevertheless, even if no evaluations of knowledge claims based on underpinning empirical evidence was found, one of the resolution strategies was conceptualized as 'evaluation of knowledge claims'. This characterization was used because there were still found instances where pupils judged the trustworthiness of knowledge claims, or described criteria for such evaluation, but without focusing on underpinning empirical evidence. A crucial point here is that these criteria were applicable without any knowledge of the specific source of the information, and therefore were viewed as evaluations of the *knowledge claims* and not of their sources.

All the pupils interviewed had one or more criteria they used to judge the trustworthiness of knowledge claims. These criteria were used to evaluate the validity of knowledge claims offered. In this evaluation the pupils looked for aspects of a claim that could indicate whether the knowledge claim was reliable or not. For this reason the concept 'reliability indicators' was constructed to describe the different criteria that the pupils used when doing 'evaluation of knowledge claims'. That is, if a knowledge claim offered had a certain 'reliability indicator', it was taken as an indication of its content being reliable.

Several kinds of 'reliability indicators' were used. The one used by most pupils was *agreement* among researchers. No matter what source, it seemed, if many researchers agreed on a knowledge claim, e.g. a risk estimate, it was regarded as more trustworthy.

Mari, for example, gave the following answer after having said she would not trust the experts:

> I: If you can't trust the experts 100%, who then can you trust?
> Mari: You know, an expert, you are likely to trust [what he says] if there are several experts who have decided to work together and then found that this and this is right. You should trust those more. But this doesn't happen very often.

When discussing the results of the Norwegian study not finding any harmful effects, the following exchange occurred:

> I: That [the Norwegian study by Tore Tynes] is not enough to make you uncertain on your opinion?
> Nils: ... One project can't tell you very much, but maybe five, or ten. If ten different research projects had found the same, then I might have started to move towards that position.

Other ideas having a sort of social aspect were that researchers could be trusted if the claim was inside their domain of expertise, when the researcher changed his/her conclusion, or when a researcher was willing to guarantee his/her results to be true.

Another kind of 'reliability indicators' implied an evaluation of *form.* The researchers' findings would be trusted, by some pupils, if there were exact numbers in all findings, or if causal relations were found. Alternatively a statement would be trusted if it sounded serious. An example here is a statement

made by Frida:

> It depends on how the information is presented. If it looks very serious, then its much easier to trust, more than if its just a mess.

A third kind of 'reliability indicators' focused on the *compatibility* with knowledge the pupil already believes in, e.g. whether new knowledge claims are contradictory with his/her existing knowledge. Several pupils said they trusted new research results if they were understandable or seemed plausible to him/her. Asked whether he trusts new research findings presented in media, Arne says:

> If it looks logical to me, then I believe it. If it doesn't look logical, then I sometimes believe in it.

Trond gives the following answer to the same question:

> It depends on what they have found. If it's things you have some prior knowledge of you might trust it.

One pupil also said he did not trust new results when it was perceived as 'crazy'. Another pupil said he trusted the information in the leaflet on the magnetic filed strengths because it was crisp and clean.

A fourth and more fuzzy kind of evaluation based on 'reliability indicators' implied assessment of *the quality of the research. A* few pupils said they would trust the results if they turned out to be right (!), or if the method used was good. Some pupils, like Ina, wanted to wait until further research could bring about proofs, indicating that the risk estimates presented so far were not seen as trustworthy enough:

> I: What would you want to know more about, if anything, before you made up your opinion?
> Ina: Before I made up a clear opinion I would want proof on whether it was dangerous or not.… I don't think I have a good enough decision-base really. I am the kind of person who says we should wait until we get the real proofs and things like that.

This fourth kind of 'reliability indicator' deviates from the other three as it is not aimed to answer the need for an immediate risk estimate for the decision on the issue.

The findings here characterized as 'evaluation of knowledge claims' can be said to imply the use of the different 'reliability indicators' as tools to sort out what knowledge claims to trust or distrust. This is of course not to say that all these 'reliability indicators' are strong, adequate or relevant tools for judging trustworthiness.

Several authors have pointed to the problem that standards needed for evaluation of evidence underpinning scientific knowledge claims are beyond the reach of non-experts (Hardwig 1985, Single and Gaskell 1994, Norris 1995). One answer to this observation has been to discuss the legitimacy of evaluations based on different kinds of contextual factors and social information (Lehrer 1977, Siegel 1988, Bingle and Gaskell 1994, Norris 1995). This is an aspect that will be discussed later. Here I want to ask whether the 'reliability indicators' used by the pupils in this study can be said to point towards an *alternative* to evaluations based on empirical evidence. After all, it is my impression that most of us, scientists or not, ourselves use different ideas, like lack of contradictions with what we already know, when evaluating disputed knowledge claims encountered outside our own domain of expertise. Such criteria might also be conceptualized as 'reliability indicators'.

If the concept of 'reliability indicators' can be viewed as relevant for the discussion of lay people's evaluation of knowledge claims, one needs to discuss the validity of different 'reliability indicators' used by the pupils and others. Could some of them be viewed as relevant enough to be emphasized in science education? And should some of them be discussed e.g. in the science classroom and sought shown to be inadequate?

Resolution strategy 2b: 'autonomous evaluation'

One resolution strategy, interpreted to imply evaluation of statements, was conceptualised- as 'autonomous evaluation'. The following two quotations provide examples of the kind of statements interpreted to indicate an autonomous evaluation of knowledge claims, arguments and/or opinions to be made by actors involved:

> I: Who did you think it was naturally primarily to listen to when you made up your opinion?
> Aud: First and foremost those who live there. ... And then of course science, I think. You know, I'm not such a very science-minded person, but when it comes to facts, like 'this is the way it is', then I trust those researchers who are knowledgeable on that. But then the researchers might disagree, but then I have to think for myself, so to speak, what I think is the best in a way.

> I: On the work sheets from the group discussion you wrote 'one should trust the researchers, we don't trust BKK'. You know you could have written that 'We trust the researchers', but you wrote that one 'should'. How did you think about that?
> Ivar: One should not trust them totally, I think. No, we should not. We should listen to them, but not trust them totally.

About half of the pupils made statements like these, and several of them seemed to be very clear on the view that one has to 'think for oneself. What is most interesting about these pupils is not that they seem to perform autonomous evaluations. All pupils who evaluated information or its sources can be said to have done that to a greater or lesser extent. The most interesting aspect, in my view, is that they state this more or less explicitly. This indicates that they are *conscious* that one might, or has to, think for oneself.

Several of the pupils who used this resolution strategy, and none of the other interviewees, also focused on the importance of listening to all actors involved before making a final decision:

> I: What do you think one ought to know concerning power transmission lines, cancer and risk before one makes up an opinion that one thinks others should listen to?
> Unni: I think you have to listen to both sides. Those who have the opinion that it [the power transmission lines] is *not* dangerous, and those who have the opinion that it *is* dangerous.

> I: Some people hold the opinion that it is more naturally to use language lessons for discussions. In science lessons one have to concentrate on what is in the textbook. What is your opinion here?
> Ivar: I think it fits in just as well in science class, like we have been doing now, because there are so many opinions. It is about vague things, there is no one who really knows, then it is OK to listen to everybody.

These and similar statements about the importance of listening to different actors were also interpreted to imply the idea that the opinions of different actors have to be compared and autonomously evaluated by the pupil him/herself.

Only about half of the pupils made statements categorized as 'autonomous evaluation'. Whether the other pupils interviewed had an unarticulated consciousness of a need for autonomous evaluations is not possible to know. This lack of articulation of the need for autonomous evaluation might still be interpreted to indicate that not all pupils were *conscious* of a necessity to perform autonomous evaluations.

Third resolution strategy: 'acceptance of authority'

The third kind of resolution strategies identified involved pupils' plain acceptance of potential sources of information, without giving any reasons for their choices. It should be mentioned here that in the interviews the pupils were seldom provoked to give reasons, but most of them very often still gave reasons for their views and opinions.

Resolution strategy 3a: 'researcher confidence'

The most frequently mentioned source for information was researchers who had worked on the issue. This was no surprise, as the research findings were at the heart of the issue, and as these were discussed in the newspaper articles presented in the preparatory phase.

Most pupils gave reasons for their trust in researchers at least at some points during the interview. Some pupils, however, made statements implying acceptance of researchers as authorities, *without* making other statements during the interview where reasons for their acceptance of researchers as trustworthy sources were given. The following quote was, for example, interpreted to involve acceptance of researchers' risk estimates without this to be seen as problematic, and without any reasons given:

> I: You ticked the option for the transmission lines to be put underground. Could you tell me what *your* most important arguments are?
> Unni: In fact, the most important argument is that they say there is a risk for cancer if you live near them [the power transmission lines]. And there is higher radiation and risk from those [lines] in the air than from those in the ground.

This resolution strategy, trusting researchers without evaluating them as sources, was categorized as 'researcher confidence'. In her study on adolescents' ability to interpret media reports of scientific research Ratcliffe (1999) made a similar finding. She found that some of them used the authority of scientists when they wanted to argue their view on whether a knowledge claim could be regarded as proved or not.

An interesting additional finding was that some pupils stated that they had totrust the researcher, as there was no alternative to this:

> I: Do you think the local residents are sceptical on whether the researchers have been neutral and such things?
> Ina: Yes, I think they are. But this is the problem here, that you just have to trust them [the researchers]. Because, who else could you listen to?

This pupil's analysis expresses much about how some, if not most, pupils experienced the situation. The researchers were recognized as the primary source of the important information on the risk estimates, or as another pupil put it:

> 1: Once you said [during the group discussion], and maybe you were a bit ironical, 'we have to listen to the researchers'. Why so?
> Arne: We have to trust the researchers because they know what they are talking about, much more than those who live there, and whose jobs are within completely other fields. What they know they have learned from the researchers, because it's they

who have told them everything.

Resolution strategy 3b: 'confidence in other actors'

The kind of view expressed by Arne above might also explain why other sources of information were seldom mentioned. The only exceptions here are some pupils who emphasized the power company or the local residents as important sources:

> I: Early in the group discussion you said: 'Who do we listen to?', and one of the girls replied: 'At any rate not BKK'.
> Finn: Well, I would not say that. In one way maybe because—, I would rather have listened to them [the power company]. . . . They have more concrete information. More facts about radiation and the magnetic stuff.
>
> I: Who do you find it most naturally to listen to?
> Brit: I listen mostly to what is said in the newspapers on the opinions of people [living near the power transmission lines]. Not so much to what BKK says and things like that.

Other authoritative sources mentioned was a political committee on health and social issues, the Norwegian Radiation Protection Authority, environmental organizations, and parents. One or two pupils only mentioned all these sources.

This weak emphasis on other sources could be due to lacking consciousness about who they really trusted. Another possible explanation is that the pupils focused on what they perceived to be the key question in this issue: the risk. The problems found to be experienced by the pupils also fit well with this last hypothesis.

Fourth resolution strategy: 'evaluation of authority'

More often than just accepting authorities, the pupils gave reasons for their choices of authorities to trust. Thus to some degree they evaluated the trustworthiness of different authorities. Alternatively they stated a criterion which a source had to fulfil to be trustworthy. A total of four different kinds of reasons and valued criteria were found. These centred around the following concepts: 'opinion on risk'; interests'; 'neutrality'; and 'competence'. These concepts were thus used to analyse sources offering knowledge, arguments and opinions for trustworthiness. All these four resolution strategies were therefore categorized as 'evaluation of authority'.

Resolution strategy 4a: 'analysis of opinion on risk'

Some pupils stated that one should trust those who emphasized the risk:

> I: Do you have any idea as to how the politicians can know which researchers to listen to? Because, I have understood that your impression is that the researchers have reached different results.
> Unni:… In my opinion, they [the politicians] should listen to those [researchers] who say it's dangerous. Because if you do something about it, and it is not dangerous, then there is no problem. But if it is dangerous, and they don't do anything, then it will have harmful consequences.

The value 'play safe' was applied by some pupils, like Unni does in this quotation. These pupils focused on authorities' evaluations of the risk estimates and chose to trust those who seemed to share their values on the importance of avoiding risks to health. By doing this the value 'play safe' was used as an analytical tool to judge trustworthiness. Some pupils also said they would trust those who agreed with their own view on the issue:

> I: In the group discussion, Anne said that 'At any rate we do not trust those who says that it's not carcinogenic'. To what degree do you share her attitude or scepticism? Sara: Really a lot. No, I just think it sounds more probable that it [the power trans mission lines] causes cancer and is more dangerous, and then I will listen more to those who agree with me.

In addition one pupil said he would *not* trust those who focused on the risk. All these views were based on a personal value position. Through looking for sources sharing his or her values, and thus opinion on risk, this position was used to establish a resolution strategy conceptualised as 'analysis of opinion on risk'.

Resolution strategy 4b: 'analysis of interests'

'Analysis of interests' was another resolution strategy found to be used to evaluate authorities. The strategies 'analysis of interests' and 'analysis of opinion on risk' have some similarities, as values play a central role in both. On the one hand, interests can be said to express values, and on the other hand emphasis on low or zero risk is a value position. But there is also an important difference between these categories. When analysing for opinion on risk, the source's opinion is in focus, and not what values the source projects. When analysing for interests, the values perceived to be held by the source are in focus.

Less than half of the pupils used the idea of interests explicitly to judge trustworthiness. Several of these stated that they would not trust the power company

I: You once mentioned [during the group discussion]: 'It is important not to trust the power company'.
Nils: They [the power company] have clear advantages in such issues. They can't evaluate from an unbiased point of view, because, as I've already mentioned, it is cheaper for them [not to put the lines underground].
Bard: If you asked me who I would have trusted, I would have trusted those researchers who said there was a small risk. Much more than the power company, because they just want to make profit on this [the building of the lines], or not to lose money. The researchers don't have much money to gain from it.

In the second quotation here we observe that researchers in general are seen as less subjected to interests than the power company. But there were also pupils who stated that researchers working for the power company, or researchers living very close to the lines, should not be trusted. A few pupils mentioned more explicitly that the local residents, and environmental organizations, were not to be trusted:

I: Could it have been interesting to know more about the opinions hold by the residents, or environmental organisations, or people you know, before you made up your mind?
Ina: Yes, but I believe environmental organisations and those who live there, they are afraid, and they want to influence me to be strongly against it [airborne lines], and so will the environmental organisations too, cause they don't want these power lines. So both those groups, I think, want to influence me to be against it.

Only one pupil stated distrust of media because of their perceived interests due to the owners' positions. Another pupil expressed a general distrust in presentations of environmental issues in the science textbook because he perceived them as one sided.

As in the above quotations, interests were primarily used to sort out whom *not* to trust. A few pupils, however, used ideas of interests to explain why they trusted the figures on magnetic field strengths presented in the leaflet made by the power company. They argued, as mentioned earlier, that the company would lose all its credibility if such facts turned out to be wrong.

A connection between interests and trust in scientific (and other) knowledge claims has also been found in other studies (Layton *et al.* 1993, Irwin 1995, Irwin *et al.* 1996, Wynne 1996, Korpan *et al.* 1997, Ratcliffe 1999). However, the most striking finding in the present study concerning interests was that just about half of the pupils made statements where trustworthiness was judged based on recognized interests.

Resolution strategy 4c: 'analysis of neutrality'

The third concept used to describe pupils' ways of analysing authorities was 'analysis of neutrality'. To analyse for neutrality might be viewed as trying to find out who is not biased by interests. In fact, all pupils who analysed for interests to sort out whom *not* to trust also used concepts like neutrality, disinterestedness or 'with no opinion' when talking about whom they *would* trust.

The distinction between the categories 'analysis of interests' and 'analysis of neutrality' has been made because they rest upon different presuppositions. The first rests upon the assumption that people's interests might influence their views and opinions. This assumption is hardly controversial. To analyse for neutrality rests on the presupposition that there are some people who are neutral. When it comes to controversial issues this view might be more disputable.

The pupils analysed for neutrality by evaluating whether the source had personal gains, or by pointing to formal structures constraining the influence of interest:

I: As I understood you, you trusted him [the Norwegian researcher who found no increased risk], why ...
Arne: He had no reason to give wrong information. He had nothing to gain from doing that, he would just say it like it is.

I: It was my impression that Rita [a member of his discussion group] was afraid that if one has pre-opinions, or if one has an employer one knows wants a special result, this might increase the chance for the researcher to get just that result. What do you think about that?
Frank: About research, I think those who do inquiries in an area, especially in an area were there are different opinions, they have strict constraints around their work. ThusI don't think they make the results the employers want them to, but give neutral results building on what their studies have shown.

When pupils used the word 'neutral', they were asked what that word meant in their opinion. All pupils asked agreed that to be neutral is equivalent to have no opinion:

I: This word neutral [you just used], could you say something about what that word means to you?
Frank: I will describe neutrality as a blank sheet of paper, more or less. They have no opinions on it. They may know a lot on the subject, but not enough to make their own opinion. That's why they choose to go on with their research.

When asked, several pupils also held the view, explicitly, that it was possible to be neutral:

I: Some people maintain that it is impossible to be neutral. What do you think of that claim?
Nils: No, it is not impossible. There are people who are totally neutral. Well, it might be difficult to be neutral. You

have probably made up your mind on this issue in advance. But many researchers are like they just don't make up opinions before the results are in their hands. So I don't think its just impossible [to be neutral].

But the quotation here shows that Nils, like some other pupils, thought neutrality also could be difficult for researchers. This brings us back to the problems identified to be encountered by the pupils. How are they to know which researchers are the neutral ones? From the pupils' discussions of neutrality, it seems to be fair to say that often they do not really 'analyse for neutrality', but only state that they would trust those who are neutral.

On the other hand, Ina seems to have confidence in her own evaluation of neutrality:

I: Do you think it is possible to hear, or to see when you read something, whether they[the researchers] have a strongly held opinion or whether they try to be neutral?Ina: I would guess most of them try to be neutral, but then it [the researchers opinion] just comes through automatically.

But Frank does not seem to be sure when a researcher is neutral. When asked whether it would have been interesting to get more information on how the research was done, he seemed to want such information as it then would be easier for him to know whether it was neutral:

Frank: Absolutely. It would have made it much easier for me to know if this [research]was neutral enough to get a more exact result. More than if it was an action group*or* something like that which were not in favour [of airborne lines] who had done the research.

The overall impression is that some pupils want neutral authorities, but it is often difficult for them to know which are. It is also clear, that those pupils who want to listen to neutral sources, believes in the possibility of being neutral. This opinion is not shared by all pupils, as some of them believe that the combination of cancer and children in this issue involves too strong emotions to make neutrality possible.

Resolution strategy 4d: 'analysis of competence'

The fourth, and *mostly used tool* in the pupils' analyses of authorities, focused on the question of who is *knowledgeable*. Phrases like 'they have worked on it', 'they are knowledgeable', 'they have basis for their opinion', and their negotiations, were frequently used by more than half of the pupils:

I: On the transparencies [shown in the first science lesson in the preparatory phase] there were people from the committee of politicians, researchers, the BKK, different residents. Were some of their statements more important to you than other?

Frank: I have more confidence in those who have put more work into the subject, researchers and people who have worked on it. More than I trust a private individual who might be very sceptical towards this just because they have contact with small children and such things.

I: I understand you have made up an opinion on this issue. Who did you find it naturally to listen most to?

Mats: It's them [the researchers] who have most knowledge, who are the most knowledgeable. It's not foolishness what they say, so I would have listened mostly to them. But if there are someone who for example have a complete counter-argument and have good reasons, or good counter-arguments against something, then it's worth listening to those also.

I: You once said [during the group discussion]: 'In a way we have to trust someone'. Can you elaborate on what you meant here?

Karen: ... I'm not completely sure what I meant, but it probably was that we have to try to find out who is most right, who have the best basis for saying this or that is right. So I think it's the researchers we preferably will believe, as it's they who have worked much on it.

Statements like these gave rise to the resolution category 'analysis of competence'. At first glimpse, concepts like 'knowledgeable' might look like applicable tools to use, but an important question seems to be only superficially answered by the pupils: How are we to know who is knowledgeable within different fields of knowledge? Several pupils explicitly mentioned that the researchers were knowledgeable because they had 'worked on the problem'. Clearly the pupils can draw upon their general social knowledge on competence associated with different occupations. But this would constitute a very coarse analytical tool, hardly useful for differentiating between disagreeing experts.

And two pupils took the members of the committee on health and social issues in the community to be knowledgeable experts, although all members were democratically selected politicians. This might be due to imperfect knowledge of the way democracy is run, or due to superficial reading of the source commented upon.

It could also be asked to what degree the pupils were *analysing* for competence when they used different ideas of 'competence' as analytical tools, and to what degree they just appreciated competence. It is here worth noticing that the pupils Quoted were both arguing and discriminating, in using concepts like 'knowledgeable'. On the other hand, their articulated analyses were shallow, and did not discriminate between

different experts. But, interestingly enough, this was what some of the pupils tried to do by analysing for interests and neutrality.

Yet, the most basic problem articulated by the pupils, expert disagreement and '"conclusive science, did not seem to have any easy attainable solution. Those knowledgeable in the field would presumably be the first ones to state the uncertainties in the risk estimates offered. The core of the 'problems encountered' by the pupils could therefore not be solved by trusting those knowledgeable. But, on the other hand, this does not imply that this concept has to be dismissed as a relevant analytical tool. Not all experts are experts in all fields, and not all experts are equally knowledgeable. There is obviously room for improvements in the pupils' notions of degrees of expertise.

Discussion

The findings presented show that the pupils used a range of strategies in trying to decide who to trust and what to believe. They analysed statements using different 'reliability indicators', and analysed potential authoritative sources for their competence, interests, neutrality and opinion on risk. In addition, it was found that knowledge claims not being questioned by any actors in the controversy were taken for granted as trustworthy by the pupils. On the one hand, all pupils made at least *some* statements that were categorized as involving analysis of knowledge claims or sources. On the other hand, some pupils seemed to accept researchers as authoritative sources of information, without arguing for them to be knowledgeable or giving other reasons for their trust.

A striking feature of the pupils' relation to researchers and their findings was their *complex* views. On the one hand, the researchers were analysed for interests, neutrality and opinion on risk, and many pupils found it difficult to fully trust the researchers and their research methods. On the other hand, more or less all pupils expressed trust in research and researchers, and found it natural to turn to the researchers for knowledge of the risk.

This two-sided view with a mix of trust and scepticism can be conceptualized as a *dual attitude* towards research and researchers. The most interesting feature of this dual attitude is that it does not imply that some pupils were sceptics, while others trusted research and researchers. On the contrary, the dual attitude was found to be characteristic of the thinking of most of the pupils interviewed.

A somewhat similar differentiated relationship toward research was also found by Wynne in his study on highland sheep farmers in Cumbria, Britain, in the aftermath of the Chernobyl accident. For several reasons, the farmers were very sceptical to many claims proposed by the scientist advisors. Still farmers 'gathered—and used—evidence which was drawn from science' (p. 31).

Also the pupils' views of the power company involved were found to be differentiated. On the one hand, this was the actor most consistently associated with interests, interests assumed to make it less trustworthy. On the other hand, the pupils reserved their scepticism about the company's risk evaluations and opinion on the issue, while accepted their claims concerning magnetic field strength from different sources and concerning increased costs and problems with error detection and repair if underground cables were chosen. This shows that the pupils were *nuanced in their scepticism* against the power company, and some pupils even stated this differentiated view explicitly.

In the analysis and categorization words like *analysis* and *evaluations* have been frequently used to characterize the pupils' ways of trying to deal with the trust question. In my view, these approved concepts have been adequate to use. My argument here is that the pupils frequently and unprovoked gave reasons for their views and choices. At some occasions, pupils stated in more hypothetical terms that they would trust those who were neutral and knowledgeable. But most often a reason was given, like stating that researchers were knowledgeable as they had worked on the risk question, or that the power company was not trustworthy as they were interested in profit.

Nevertheless, to characterize the pupils' strategies as partly involving analyses and evaluations is not to say that these evaluations were advanced. On the contrary, their analyses as offered in the interviews were rather shallow. They wanted to listen to the disinterested and neutral researchers, but few of them expressed any ideas as to who that might be. They wanted to trust those risk estimates that several researchers agreed upon, but they did not indicate how they were to judge the level of agreement. Neither did they differentiate between more or less knowledgeable researchers.

Disagreement among researchers and the social processes in science

The pupils' basic problem, disagreement among the researchers, was not resolved by their analyses. Their impression that the researchers disagreed, or did not know the true risk, seemed to be a frustration to the pupils even if the interviews were performed several days after most of them had made their decision. The science encountered in the issue of power transmission lines can be classified as disputed, non-consensual

frontier science. Most of the science pupils learn through schooling can be classified as undisputed, consensual, textbook science. It should therefore come as no surprise that the knowledge about the nature of scientific knowledge production they had picked up through schooling was not sufficient to make them understand or appreciate the uncertainties and the spread in the risk estimates in the relevant studies. A similar point was also made by Norris and Phillips (1994) when commenting their finding that 'Students systematically overestimated the reported truth of statements' (p. 959) when judging degree of reported certainty after reading popular reports of science.

Important aspects of science are the social processes where ideas and results are reported, peer reviewed, debated and scrutinized (Ziman 1991, Bauer 1994, Driver *et al.* 1996). In this picture, the debate over different findings is an important part of the process that seeks to validate scientific knowledge claims. Knowledge of this aspect of science might prevent the interpretation of disagreement between researchers in terms of interests and incompetence, without further evidence for this to be the case. Interpretations in terms of interests and incompetence were reported by Driver *et al.* from a study on how 16-year-old pupils explained perceived disagreement between researchers. Two issues were used in their study. The hypothesis of the drift of continents involved in the theory of Plate tectonics, and the current debate on the safety of food irradiation. The importance of interests in judging credibility was also found in a Canadian study interviewing 12-year-old pupils on several current controversial issues (Gaskell 1994). These findings have also been replicated by the study presented in this article.

Analysis based on contextual information

In this study instances were *not* found where pupils tried to analyse knowledge aims in relation to underlying empirical evidence. It *was* found, that most pupils evaluated *sources* of knowledge more than they evaluated the content of statements. Munby (1980) has argued that 'intellectual independence involves the capacity for making judgements about knowledge claims for themselves' (p. 19). But several authors have argued that to scrutinize empirical evidence underpinning scientific knowledge claims is out of reach for most people (Hardwig 1985, Gaskell 1994, Norris 1995). Bingle and Gaskell (1994) have stated that 'only scientists themselves have access to the standards which are necessary to make an evaluation of what they do' (p. 198). In his discussion, Hartwig (1985) concludes that non-experts are frequently epistemically dependent on experts, a conclusion also approved by Siegel (1988). If lay people are to evaluate scientific knowledge claims, it therefore seems to be necessary for them to look for other analytical tools than those that make examination of empirical evidence possible.

Concerning contested science, Bingle and Gaskell (1994) maintain that 'From a social constructivistic point of view, it is appropriate for citizens to evaluate the importance of contextual factors to the scientific claim being made.' (p. 191). As examples of contextual factors they mention the role of gender, the source of funding and personal prestige or charisma. Norris (1995) has argued that 'the proper attitude for non-experts to have toward scientific experts is … to judge the grounds for their claim to expertise before willingly consenting to recognise that expertise' (p. 213). But this leaves us with a question: what are proper grounds for such judgement? Norris mentions the role and weight of consensus, publication, prestige in the scientific community and more, as examples of criteria for judging experts. Siegel (1988) has listed a range of considerations one has to undertake to judge expertise, e.g. the expert's competence, agreement among experts, honesty and conflict of interests (p. 2). These aspects resemble the concepts identified as used by the pupils in the study reported in this article.

One should be aware, though, that using the kind of contextual information discussed by Bingle and Gaskell, Norris and Siegel does of course not imply truth to be more easily accessible. Recognizing such information as legitimate and relevant only implies acknowledging that all expertise and scientific knowledge claims exist in a social context, and that contextual social factors then somehow might influence the judgements made by scientific expertise.

Norris (1995) concludes that 'pupils need to be taught that the object of their scepticism should be the believability of experts, not the evidence supporting scientific knowledge claims' (p. 216). The study reported in this article, however, indicates that most pupils already put this into practice. What appears to be a problem though, are the pupils' shallow analyses. The pupils were found to build on very general impressions concerning who is knowledgeable, and who is subjected to interests. What the pupils therefore seem to need is more knowledge of different kinds of institutions offering scientific knowledge claims, and an increased interest in more detailed contextual information.

The only contextual information nearly all pupils mentioned as relevant was the level of agreement among researchers. But, as stated above, in their judgement of the level of consensus the pupils appeared to build on a superficial impression from their readings of newspaper articles presented, an impression that also seemed to be influenced by the power company's claim that no risk had been proved.

Resolution strategies involving autonomous evaluation

Two of the main resolution strategies identified in this study involved evaluations to be made by the pupils. They evaluated *statements* by using 'reliability indicators' and by emphasizing the need to think for themselves. They also evaluated *sources* of information by analysing for interests, neutrality and competence, and a few of them also by analysing for opinion on the risk. This evaluation of information and its sources, as opposed to plain acceptance, implies that the pupils performed autonomous evaluations. But, in addition, all the pupils interviewed also accepted certain knowledge claims without any evaluation, and many of them also expressed general and unconditioned trust in researchers (and sometimes in other sources of information). Even so, it seems right to conclude that many pupils, through their autonomous evaluations, to some degree practised intellectual autonomy.

Intellectual autonomy involving autonomous evaluations is a highly valued aspect of rational decision-making, according to the tradition stemming from the Enlightenment period in Europe. These findings might therefore be viewed as very encouraging. A handful of interviews is of course not enough to evaluate to what degree pupils' ways of dealing with the issue of trust in general involve intellectual autonomy. The analysis presented nevertheless indicates that most pupils *try* to do autonomous evaluations when they realize that there are diverging views on important aspects of an issue, even if these evaluations seem to build only on shallow contextual information.

One should be careful to suggest implications for science education from one single study. One topic for inclusion in science teaching for citizenship will nevertheless be suggested here: training in evaluation of sources of both conclusive and inconclusive science. To guide such evaluation, knowledge of the characteristics of different kinds of sources of science-based information should be included. This will imply a dramatically increased emphasis on science as a social institution, and thus expanding the view of science as knowledge products and processes to make these products. I believe Unni's answer below makes my point clear:

> I: Who do you find it natural to listen to when you are to make up your mind on this issue?
> Unni: I really don't know. I just haven't thought about that.

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