Chapter 6
Social Aspects of Argumentation

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Studies on students' argumentation, particularly on science-related issues, show that social dimensions influence argumentation (Grace, 2005; Kolstø, 2006; Mercer, 2000; Solomon, 1992). The purpose of this chapter is to explore some of these social aspects and discuss their legitimacy and possible consequences for teaching argumentation in science education. The scope for our exploration is the social aspects of argumentation in science-related issues. We conceptualise argumentation as a goal directed social practice embedded in different types of dialogues (Walton, 1998). The nature of argumentation will be discussed from both a philosophical and an empirical point of view. In addition, we will also relate the discussion to social aspects of science in order to clarify the context in which students' argumentation on scientific matters are embedded. We define an argument as a claim supported by a justification. The characteristics of justifications are not included in our definition, as the quality of the justification, according to the nature of arguments, is to be judged by the debaters.

In their seminal article "Establishing the norms of scientific argumentation in classrooms", Driver et al. (2000) identified two main reasons for teaching argumentation in science education. Firstly, it is important to convey to students an adequate image of science, especially to show the socially constructed nature of scientific knowledge. Such social construction emphasises science teaching as a discursive practice and encourages argumentation in science. Secondly, it is regarded as critical that young people are enabled to construct and to analyse arguments related to the social applications and implications of science. Specifically, this involves the ability to engage with claims from the frontiers of science involved in controversial socio-scientific issues (see Chapter 12 by Simonneaux for an elaboration on this aspect).

In line with this twofold justification, we will focus on two main types of contexts in the science classroom where students might get involved in argumentation. Firstly, there are scientific issues which, to some extent, are detached from possible social implications (e.g., when students discuss possible interpretations of their experiments). Secondly, there are issues where the science is involved in a social debate. Typically, such issues concern personal or political decision-making related to health and environmental controversies. Examples here are the climate issue and genetic testing. In addition there are issues related to science policy (e.g., what

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research to allow or to support). Both types of issues are influenced by the social aspects of the conduct of science.

In this chapter we will argue that scientific argumentation does involve certain social aspects and that to some extent this might explain the presence of social aspects involved in students' argumentation in science-related issues. Our main thesis is that the influence of social dimension on students' argumentation in relation to scientific claims is legitimate and desirable. Thus social dimensions should be a focus in science teaching. In some contexts this includes the critical use of arguments from scientific experts. We also argue that the accuracy of students' argumentation will prosper from increased insight into social aspects of science, because of the importance in contextualising science issues.

Argumentation as a Social Activity

We start by discussing the implicit claim in the title of this chapter, the assertion that arguments have social aspects. Van Eemeren et al. (1996) state that there are three generally recognised forms of argument: analytical, rhetorical and dialectical. Analytical arguments belong to the domain of formal reasoning. Formal reasoning is concerned with the logical structure of arguments, and whether a conclusion follows logically from given premises. However, scholars have claimed that formal logic is inadequate for describing argumentation in science (Walton, 1992) and irrelevant for inclusion in science teaching (Driver et al., 2000) and will therefore not be discussed here.

Reasoning which does not employ formal logic is denoted as informal reasoning. Thus informal reasoning employs rhetorical and dialectical forms of arguments. Rhetorical forms of argumentation refer to arguments used in monological situations where an orator employs discursive techniques in order to persuade an audience. In contrast, dialectical forms of arguments are involved in dialogues involving two or more discussants.

Argumentation in informal reasoning therefore apparently exists in two forms: individualistic or social. The individualistic meaning relates to rhetorical and other situations where an individual formulates a point of view. The social meaning of argument refers to a dispute between people. However, we will nevertheless claim that all argumentation is basically social, as rhetorical arguments expect an audience. This view is supported by Billig (1996) who claims that the existence of two meanings of "argument" signifies the importance of the possibility of contradiction when exploring questions. This focus on contradiction, Billing states, was probably first noticed by the ancient Greek philosopher Protagoras who claimed that in all questions both pro and con arguments can always be found. From this assertion he concludes that any single opinion or "individual argument" is controversial, and thus actually or potentially a part of a social argument. Consequently, we will take the view that argumentation is basically social and operates in a social context. Our question is therefore not whether social aspects influence debaters' argumentation, but what these social aspects are, and how they influence on argumentation in science-related issues?

This basically social function of arguments is apparent in science where the authors of scientific articles carefully build up arguments using the kind of rhetorical devices valued and accepted in science. However, this individualistic practice serves a social function as each paper is a contribution to a debate among colleagues in a scientific community. Moreover, consensual conclusions on facts, models and theories in science will be backed by arguments produced by several contributors, and based on the judgement of a scientific community as a whole. Consequently, argumentation in science has a social purpose and an ultimate goal: contributing to the collective development and judgement of scientific knowledge claims and the identification of reliable and consensual descriptions of nature.

When designing curricula and activities in science teaching aiming at fostering skills in argumentation, we need to take this social and goal-directed purpose of argumentation into account. However, argumentation might have different social goals in different contexts and situations. In the next section, we will have a closer look at different social goals and their relevance for science teaching. We will also present examples of how science students in different contexts construed the social goal of their argumentation.

Argumentation and Types of Dialogues

Whether debaters might meet face-to-face, through texts or by other means, an argument is always made in a context where debaters exchange views. Such exchange of views is what characterises dialogues (Walton, 1998). Therefore, arguments are embedded in dialogues, and this dialogical and social context will influence the characteristics of arguments put forward. In order to understand social aspects of arguments we therefore need to take into account social aspects of dialogues.

Studies of students' argumentation in dialogues on scientific and other issues have revealed that students' dialogues may take different forms. Studying small group discussions Mercer (2000) identified three different types of discourse; disputational, cumulative and exploratory talk. *Disputational talk* is competitive in nature, differences of opinion are stressed rather than solved. It is characterised by exchanges of claims, challenges and counterclaims, with students defending their own point of view. *Cumulative talk* is characterised by agreement, and typically features repetitions, confirmations and elaborations. *Exploratory talk* involves presentation of points of view backed up by arguments and critically but constructive discussions about each other's ideas.

In her study on science students' discussions of the types of management of wolves to implement politically in Norway, Mork (2006) found all these kinds of talk represented. She also claimed the need for an additional version of disputational talk which she calls *reasoned disputational* and is characterised by claims supported by a reason. From her excerpts it is evident that all arguments are put forward in response to other utterances, and thus occur in a social context where all participants have their own roles, agendas and expectations, and interpretations of what characterises appropriate contributions.

Focussing on arguments as embedded in dialogues with different goals, Walton (1998) presents a classification of dialogues which attempts to cover all kinds of argumentative interactions (see Duschl, this book for an extended discussion of Walton's categories). Walton defines dialogue as "a normative framework in which there is an exchange of arguments between partners reasoning together in turn-taking sequence aimed at a collective goal" (p. 30). He claims the existence of five different types of dialogues, characterised, among other attributes, by different *goals*: persuasion dialogue (e.g., critical discussion), information-seeking dialogue (e.g., interview and expert-consultation), negotiation dialogue (e.g., deal-making), inquiry dialogue (e.g., scientific inquiry and public inquiry) and eristic dialogue (e.g., quarrel). Walton's types of dialogues are analytical categories and he does not claim the empirical existence of these in their pure form. Also, in a discussion there might be one or several shifts between types of dialogues, with accompanying shifts in goals pursued.

Although there are slight differences, Walton's concept of persuasion dialogue has clear resemblances with Mercer's Disputational talk and Costello and Mitchell's (1995) competing type of argument. Moreover, the goal involved in inquiry type of dialogue is not very different from the purpose of Mercer's Cumulative talk and Costello and Mitchell's consensual type of argument. In our discussions we will use Walton's analytical categories due to their claimed applicability to describe dialogues involved in different disciplines, including science.

Given these different patterns of dialogue, science teachers may need to be conscious about the kind of dialogue they want their students to engage in, and to design the educational context accordingly. Additionally, if we want to convey to students an adequate image of science, we need to identify characteristics of argumentative discourses in science.

Although students may engage in all categories of Walton's dialogue, we would argue that two in particular are important as representations of scientific practices. The critical discussion as a type of persuasion dialogue and scientific inquiry as a type of inquiry dialogue are of social interest in our context, due to their possible relevance for describing scientific discourses. In a persuasion dialogue in general the goal of each party is to persuade the other party to accept an assertion, using, as premises, data and ideas that the other party has accepted as decision-base. In a critical discussion, as a specific type of persuasion dialogue, the goal is to solve a conflict of opinion by means of rational, or reason based, argumentation (Walton, 1998).

The method of critical inquiry is to look at arguments on both sides and raise critical questions of these, in order to identify the strength of the arguments involved. The participants typically proceed by question and reply. Participation in a critical discussion presupposes a willingness to change view in light of good arguments. If a debater is not open to change his opinion she has in fact shifted the dialogue into an eristic dialogue (e.g., quarrel) (Walton, 1992). In an eristic dialogue the defining goal is to win and not to test the strength of arguments.

In a scientific inquiry the goal is for the participants collectively to establish or demonstrate a particular scientific claim based on scientific criteria established in a scientific community (Walton, 1998). The method of scientific inquiry is therefore to collect all relevant evidence, scrutinise this evidence and through collaboration and argumentation identify conclusions that are firmly supported by theory and evidence. The goal of identifying a conclusion implies a need to restrict the ongoing critical questioning in order to proceed towards a result.

Which kinds of dialogues are practised in science then? Walton (1998) argues that the presentation of scientific results in scientific papers to some extent does have the characteristics of scientific inquiry as a type of dialogue. However, science at the laboratory stage, where researchers work together to identify, discuss and test different possible phenomena and explanations/hypothesis, probably has other characteristics. At this stage of scientific knowledge production the discussion is probably best described as alternating periods of scientific inquiry and critical discussion among collaborators. In addition, sociological studies of science indicate that disputes in the public sphere between scientists on competing theories are best characterised as persuasion dialogues or critical discussions (Latour, 1987; Martin & Richards, 1995).

Researchers' analyses (Costello & Mitchell, 1995; Walton, 1998) provide us with the insight that humans employ different kinds of dialogues for achieving different type of goals. Their analyses inform us that argumentation is embedded in different types of dialogues and also in a wider context which influence the kind of goals, and thus kind of arguments which are put forward.

Scientific Inquiry and Critical Discussion in the Science Classroom

Based on the idea of arguments as embedded in goal-directed dialogues, what might be the consequence for the teaching of argumentation in science? Referring to Aristotle, Walton (1992, Chapter 1) claims that, due to its goal and method, participation in critical discussion does not presuppose subject-matter specialisation on behalf of the participant asking critical question. Participants might, however, need information from experts and thus shifts to periods of expert-consultation dialogue can occur. Such expert-consultation improves the level of the critical discussion, but in general critical discussion might be practised at any level of expertise.

Participation in a scientific inquiry dialogue, however, does presuppose knowledge of relevant subject matter. This is so because alternative explanations or hypothesis need to be developed and explored, and also need to be based on, or at least not contradict, established theories in the relevant field of knowledge.

The claim about different demands on subject knowledge has an immediate consequence for science education. If we want students to practise a critical discussion, the depth and breadth of their knowledge-base may be at any level, and this level might be decided by the teacher. We might even decide that the students shall include expert-consultation dialogues and gather the necessary information and decide on the level or quality of the critical discussion themselves. In addition, we might want to train students in drawing evidence-based conclusions on scientific questions or decisions on socio-scientific issues and making their arguments available for others to inspect. This implies performing inquiry types of dialogues, which presupposes a more extensive knowledge-base. There might therefore be three relevant kinds of dialogues for developing increased competence in examining scientific and socio-scientific issues through science education: critical discussion; expert-consultation dialogues; scientific inquiry dialogues.

In a study conducted in a science class, 14-year-old students were presented with a decision-making task—what materials would they use for making window frames? They were given some information about the common materials used—aluminium, PVC, softwood, hardwood (Ratcliffe, 1996). The peer group discussions had the elements of persuasive dialogue with a small amount of critical reflection. For example, although pupils were able to comment on the advantages and disadvantages of materials (though not systematically) the dominance of one individual's view could sway others without much thought. A typical exchange between three boys, represented here as pseudonyms Eliot, Simon and Gurwant shows how Eliot develops his initial solution with the acceptance of the other two boys.

Eliot:	I think we should use PVC (for the material).
Simon:	But, look it's expensive.
Eliot:	But I think it will last a long time.
Gurwant:	I think we should change the windows.
Eliot:	Yes—as I said, change the windows to PVC.
Gurwant:	OK, because this will be the most efficient.
Simon:	And it will be cheaper in the long run.
Gurwant:	PVC will be the most efficient.
Simon:	OK (writing) we have chosen PVC because it is cheaper in the long run.

The students had no systematic introduction to the nature of critical reasoning—suggesting that presentation and critique of arguments might be beneficial in their development of skilful and critical dialogue. Eliot's ability to persuade his peers might be explained as based on his charisma, or his peers' wish of "just getting the task done".

It is relevant to ask whether a different design of the task, involving higher demands on justified conclusions on all alternatives, could have stimulated students to enter into an inquiry type of dialogue and thus explore the issues in more depth. Alternatively, the design could seek to stimulate a critical discussion, making it social naturally for peers to challenge (e.g., Eliot's arguments and point of view). Whatever design is chosen, students may need explicit training in the skills of critical evaluation.

In the summary discussion, the teacher asked one group their views after he had spent a little time with the group trying to explain how individual actions can accumulate and affect others:

Liam: Well we thought we'd go for uPVC 'cos it's quality and if you buy the softwood you've got to keep maintaining it. It would cost more and you'd probably end up paying as much as you'd pay for the uPVC anyway.
Teacher: Did the environmental effects have any bearing on your decision?
Keith: A little bit.
Michael: Yeh, just a very little bit.
Teacher: So that helped sway you away from hardwood?
Michael: Oh yeh, but we still think that cutting down one more trees for our bedroom window is not going to make that much difference.
Teacher: OK, do you all agree with that.
Liam: Yes.
Teacher: You didn't take my points about you're just a drop in the ocean but with lots of other drops have a large effect.
Michael: Yes, we considered that but don't think we make much difference.

This exchange suggests egocentric values are dominant in adolescents and students would require considerable evidence to shift to a more balanced viewpoint. In this case values shared among the students were used to judge the relevance of arguments proposed by the teacher. Arguments by peers may be accepted more easily or defended more robustly according to group dynamics—the impact of social relationships within a group can have a bearing on the course of the argument. Scientific evidence itself may not sway the position of individuals. This example indicates the need for challenging the range of arguments and knowledge students draw upon, including students' views, through critical discussion. However, it also exemplifies the need for developing deep insight into an issue (e.g., through scientific inquiry), in order to become aware of arguments related to the needs and consequences for others. A further challenge is that the teacher needs to monitor the discussions and judge whether he or she has to interrupt in order to make important considerations present in a dialogue. This point is supported by Grace (2005) who found that students are able to engage in critical dialogue and have their views influenced by reasoning presented by others.

In both these examples of students' argumentation their knowledge-base is incomplete and to some extent naïve, yet this does not necessarily prevent some critical discussion from taking place. However, the students were asked to make a decision, which implies performing an inquiry through identifying reliable knowledge and values and drawing a defensible conclusion. When we want students to practise an inquiry type of dialogue, an extended knowledge-base is a prerequisite. This might for instance imply that if we want students to use argumentation in the development of explanations and reports based on their own experiments, or develop decisions as in the case above, it is wise to identify subject areas where the students have a sufficient knowledge base.

If different types of discussions exist, the learning environment has to be designed to facilitate the particular kind of dialogue and arguments sought. The possible influence of the teaching strategy used became evident in a study exploring learning about social aspects of science (Kolstø & Mestad, 2005). Students in two science classes were given the research question "Why do people walk around in circles in fog and snowy weather?". The expectation was thus that students would engage in inquiry dialogue. Working in groups the students identified a hypothesis, designed and carried out an experiment and made a written report. Thereafter the student groups in the different science classes exchanged reports, and were supposed to engage in critical discussions about the quality of experimental design and result using a learning management system (Luvit). Even though several groups did discuss aspects of the methods used, several groups focussed on defending their own report, as in the following example (Mestad, 2003, p. 83, our translation):

Group 1: Therefore we think that the method/procedure used by group five … was poor. The fact is that it will not be accurate if you are drawing up where. …
Group 2: We did the drawing as accurate as we could, and yours were not that accurate either.

Instead of critical discussions these students shifted into some kind of eristic dialogue where the main goal was to defend own results and reputation. One possible reason for this is the teacher's decision to identify the two classes as two competing research institutions. The idea of competition and own institution's reputation in the public sphere therefore might have made some students to construe the dialogue and its goals in terms of institutional interests. Our conclusion so far is that the social context including learning environment and teaching strategies influences the kind of dialogues the students' practices and the kind of arguments used. In the next section we turn to the social aspects of knowledge claims.

Social Aspects of Claims: Disputability and Flexibility of Scientific Knowledge Claims

Toulmin (1958) defines arguments as claims supported by a justification. In this section we explore the social aspects of argumentation further by examining the fate of claims. The fate of a claim advanced in a dialogue depends on what the other dialogue partners do with that claim. In a critical discussion, the goal is to convince the other party. If a claim is stated, and no one criticises that claim, it is implicitly accepted as true or probable. Thus the arguer can use that claim as a basis for further arguments. In a scientific inquiry, the goal is to prove or make probable a description, a theory or an interpretation. A sub-goal is to identify knowledge-claims on which this main claim can be built. Consequently, claims put forward will either, through critique, be judged unreliable, or enter the knowledge-base for the inquiry.

Therefore, when a claim is presented, its faith in the further discussion depends upon its reception: is it accepted or is it questioned? This reception might of course be influenced by the justifications provided. However, a claim's reception is also influenced by the debaters' views on the question "What claims are debatable?".

One possible answer is that claims from experts are not debatable. This understanding was found in a study by Kolstø (2006) where 16-year-old students were interviewed about their views on the issue of power transmission lines and the fear that these might cause increased risk of childhood leukaemia. The analysis revealed that the validity of certain knowledge claims was taken for granted. To take but one example, during the teaching sequence the students were shown a copy of some figures from a leaflet made by a local power company. The figures showed, among other things, the strength of the magnetic field, measured in microtesla (μT), at different distances both from lines and cables. The magnetic field strength were shown to be considerably weaker from underground cables than from overhead lines (0.1 vs. 2.5 μT at a distance of 20 meters) except for very small distances (5 vs. 11.2 μT at zero distance at ground level). Whether pupils were in favour of underground cables (as most students were) or not, they *all* seemed to take for granted that the both these and other numbers presented were trustworthy. Furthermore, this information was often taken as a base for arguments and personal decisions on the issue.

A reason that claims were accepted without further inspection might be because they were produced by scientists. Alternatively they were trusted as they had the "fingerprint" of truly scientific facts: exact figures! In general, students' ideas about the nature of scientific knowledge probably influence students' views on whether scientific claims might be criticised. Several studies have revealed that many students holds naïve positivistic conceptions of the nature of science (Lederman, 1992). Such conceptions imply that when a quantity is measured (magnetic field strength in the study above), a new and undisputable fact about nature results. Historically science is seen as value free and objective. This view implies that scientific results are not debatable, but constitute an objective knowledge-base for discussions on non-scientific aspects of issues. The students might therefore experience conflict when asked to debate scientific claims.

A more adequate understanding of the nature of science might make it possible for students to evaluate what scientific claims to accept as reliable, and what claims to criticise for being provisional. An awareness of the importance of critique and argumentation in science is probably important to increase students' understanding of the disputability of scientific knowledge claims. This includes insights into the varying reliability of scientific knowledge-claim, as to whether they are claims from the frontiers of science, core science, or science in the process of gaining support within the relevant scientific community. However, even consensual science might become controversial if applied in contexts where some actors dispute its applicability (Kolstø, 2001b). The issue of power transmission lines mentioned above is a case in point. The claim that scientific knowledge ruled out any possibilities for a causal link between the magnetic fields involved and the development of leukaemia was challenged by epidemiological studies and later also by new theories on possible causal mechanisms (Tynes, 1996).

At the other end of the scale, not all students are uncritical to expert statements and scientific jargon. Common utterances like "They try to blind you with science" and "Speak English!" indicate that many students are aware of the need to understand a claim or an argument in order to evaluate its strength or reliability. This critical attitude should be acknowledged by the science teacher as valuable as it can help students maintain a critical stance when a claim is hard to understand (e.g., due to lacking subject-knowledge).

Awareness of the potential disputability of all kinds of claims, including contextualised use of core science, is important for full participation in debates on scientific and socio-scientific issues. Hence it will help the processes of argumentation if science teachers are aware of their students' conceptions of the nature of science and are able explicitly to develop their understanding of the nature of scientific claims.

Common observations and also some research findings (Kolstø, 2006; Solomon, 1992) suggest that students do not always make claims clear and defend these using data. On the contrary, students sometimes use vague and flexible terms, and often only hint at a point of view. Examples here are the use of phrases like "sort of", "maybe", "as far as I understand …", and the use of understatements. Also, some students, when indicating personal opinions, include qualifiers ("as long as") and guarding phrases like "not sure" and "I think" as in the following example (from Kolstø, 2006):

> Interviewer: Are you telling me that you thought it was difficult to arrive at an opinion?
> Student: I was not sure, but as long as there is a risk, I think it is reasonable that life itself has to be chosen before money. (p.6)

In her study Solomon (1992) analysed 17-year-old students' discussions of socio-scientific issues presented on television. She reports that

> it was rare to find anything resembling the "if …", "then …" of logical propositions. In their place we found rhetoric. This form of talk is marked by positive examples, estimates of likelihood, and the processes of "showing" how things might be in different contexts. (p. 438)

This, she says, implies that the students used the form of argument which historically has been compared to "the open hand", in contrast to the "closed fist" of logic (Billig, 1996), which implies that the statement is based on presumptions and not watertight logic.

Based on the different ways of expressing views described above one might claim that these students are lacking courage and ability to make clear statements and justify these. However, it is also possible to interpret such expressions as indicating an awareness of the need to make it possible to change opinion in light of new knowledge and arguments. If a clear opinion is stated, and evidence for this to be the correct point of view is put forward, then you have to admit that you were wrong if, due to new arguments, you want to change you view. Consequently, there are social costs involved. However, if you use vague and flexible terms in your utterances, you might make slight shifts in your point of view without expressing a change of opinion. If you do not have a clear opinion at the outset of the discussion, as is often the case in complex issues, then this strategy is perfectly rational. It makes it possible to change views and evaluate arguments at low cost. Consequently, this strategy makes it easier to take new arguments and evidence into serious consideration, thus fulfilling the ultimate goal of rational argumentation.

This open and flexible strategy has similarities with the consensual type of argumentation which Costello and Mitchell (1995) state is evoked when the purpose of the argumentation is to discover common perspectives or build arguments and decisions together. The flexible strategy is therefore not at odds with the purpose of scientific inquiry. Probably this flexibility also exists in dialogues between members of a scientific research team.

The insight that might be drawn from this discussion is that participators in dialogues in science-related issues in addition to epistemic purposes also pursue social purposes. Thus, in order for an epistemic dialogue to function social purposes also have to be fulfilled. The consequence for science education is that the flexible talk of many students should not be discouraged in science inquiry activities, although the need for a conclusion in the end should not be concealed.

Nevertheless, the flexible strategy is at odds with the purpose of critical discussion as such dialogues presuppose a willingness to make confrontational questions and statements. In a critical discussion it is also important to know what points of view the different participants hold in order to know what points of view to criticise. Once again, it is therefore paramount that the science teacher is conscious about what kind of dialogue he or she wants to promote, and teach and design activities accordingly.

Social Aspects of Justifications

The role of a justification in an argument is to underpin the claim put forward. According to Toulmin (1958), such justifications involve the use of data. In Toulmin's layout of arguments, data is a generic term which refers to all kinds of evidence that might be used by an arguer to support a claim. In support of factual and causal claims, factual evidence involving empirical or theoretical statements is often used (Wood, 2000). However, the reliability of data presented is in general disputable, and this represents a challenge which also involves social aspects.

Scientific knowledge and research findings might be used as data when justifying claims in arguments on science-related issues. In fact, we might define a scientific argument as an argument where the justification involves scientific research results, irrespective of whether the argument involves a claim of fact, cause, value or policy.

The source of scientific information might be a student's own observation or second-hand scientific knowledge. However, ultimately scientific knowledge builds on information from scientists. In principle, even the student's observations typically builds on interpretations guided by scientific concepts and models learned through trust in the teacher and science textbook. Arguers using scientific knowledge in their argumentation have seldom inspected possible underlying evidence by themselves. Consequently, the use of scientific knowledge in a dialogue often implies the use of argument from experts' authority.

Rational argumentation implies, by definition, argumentation based on evidence, at the expense of basing arguments on expert authority (Siegel, 1988). Also ideals of individual judgement and cognitive autonomy point away from reliance on experts (Walton, 1997). It is nevertheless possible to argue that the use of argument from experts' authority is perfectly rational.

Firstly, the time it would take to inspect available evidence in all decision-making situations could be considerable. Experts in general, and scientific experts in particular, are involved in a range of personal and political/collective decisions. You might discuss with a friend whether to follow your doctor's advice on a health issue, or discuss with a motor mechanic who states that your car needs a new carburettor. In socio-scientific controversies, like climate issues and use of food additives, the complexity and the knowledge demands are no less. To some extent you might ask the expert to indicate the evidence base for their advice. However, at some point you have to trust their knowledge, observations and judgement if you do not want to spend considerable time learning the subject matter and skills involved. Bingle and Gaskell (1994) take an even more radical point of view and claims 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, Hardwig (1985) concludes that non-experts are frequently epistemically dependent on experts, a conclusion also approved by Siegel (1988).

Secondly, not trusting the expert's knowledge and judgement might be considered impolite, and might be regarded as cantankerous. Thirdly, progress and effectiveness in modern societies is partly due to specialisation and division of labour. The number of specialisations within science and other knowledge domains is immense. This specialisation has made the development of deep insight into narrow branches of science possible. The demand that rational debaters need to reject arguments from expert authority is therefore hardly rational. However, the use of arguments from experts' authority implies trust in the expert and his or her scientific insights. An urgent question is therefore whether scientists' knowledge claims are always reliable.

Scientific Results and Reasons for Peer Acceptance

One example of students' discussion of their own data, indicates the strong belief that students have in their own abilities to generate valid and reliable data. It also shows how students expect scientists to validate their findings. The example comes from the implementation in one school of an activity designed to help students understand the conduct and ethics of science (Fullick & Ratcliffe, 1996). Small groups of 15-year-old students were set the task of producing, within a time limit, the maximum voltage they could in an electrochemical cell, given access to a variety of metals. One member of each group acted as an observer to report how the "researchers" conducted themselves. Class discussion, which followed, was intended to draw out and discuss aspects of scientists' conduct. The focus is not the "traditional" one of reaching consensus on "what science have we learnt from this experiment?" but rather illustrating the features of how scientists might deal with: different research groups having different findings; evaluation of evidence; peer review; traits of scientific conduct. Students thus had an opportunity to engage in persuasive and critical dialogue about the validity and reliability of their results.

Although the class came to an agreement that the combination of magnesium and copper gave the highest voltage, there was no agreement, nor (intriguingly) curiosity, on the part of students as to the size of the voltage. Students argued for their original results as correct, being reluctant to repeat the experiment, and regardless of their inability to replicate the result in front of the class:

Rob: Miss, you saw that 2.08 (volts) (protesting at having to do the experiment again in front of the class).
Teacher: Well, I did that once but no-one else did.
Tom: I saw it but it's like making a food product—you've got to be able to do it again, haven't you.
Teacher: Say, Rob, you were presenting a big speech to a group of scientists from all over the world and you said I've use copper and magnesium and got 2.08 V from it—and they thought wow this is going to solve the energy crisis. They go away believing you, test their results and find you actually totally made it up, you'd lose your credibility rather quickly wouldn't you.

The teacher does not really believe the reliability of high reading on the voltmeter (2.08 V being higher than the theoretical possible value) but exposes that implicitly rather than explicitly. So there are hidden aspects to the exchange: the students have confidence in their experiments—they read the voltmeter as 2.08 V but the teacher thinks it should not be possible. The ensuing discussion centred on how scientists' results gain credibility. Most students argued for data validated by joint observation (video camera, other scientists' observing) rather than by "standard techniques" of presentation of repeated readings, estimation of errors etc. The teacher in her leading of the discussion focussed on the way students had selected materials. Students were making judgements about the results using their own values of "fairness" and confidence, or otherwise, in their practical ability:

Teacher: This group did exactly the same as yours but got different results.
Rob: Yeh, but was it on the same poles?
Nick: And was it the same amount of acid and did it have bits in?
Rob: And was it the same beaker?
Nick: And the same magic powers?
Teacher: Now Becky's not happy with this because she thinks she's done it carefully.
Rob: Hers was rubbish.
Becky: Ours was higher than theirs—they couldn't show theirs even when they tried to. (exchange continues at length each arguing why their result is correct)

This exchange shows that students bring their own values to bear in making the judgement as to what they will accept as correct—with "fairness" being interpreted in a number of ways. Teachers might expect students to accept fully the fundamental scientific truths they dispense (i.e., a belief in the teacher's authority as scientific expert). However, the exchange in terms of acceptance of experimental results suggests students are prepared to argue for their own cause regardless of any perceived authority of the teacher:

Teacher: You say you got 2.08 volts. Prove it.
Rob: You saw it.
Teacher: I did but Becky didn't.
Tom: I saw it.

Teacher: She might not believe you.
Rob: There's three witnesses.
Tom: It's up to them whether they believe you.
Rob: There's the teacher—you've got to believe the teacher.
Bill: Not necessarily.
Ben: I never believe the teacher.

The teacher may be seen as being the expert in scientific knowledge, but, in the eyes of these adolescents, not a strong influence on students' opinions. However, the students and the teacher might have construed the goal of the task differently. The teacher wants the students to practice the norms in science, which includes ability to replicate an experimental result on demand. The students operate within an everyday discourse where it is not custom, or natural, to do things twice when the problem is already solved. Thus they prefer to use their own values and criteria when judging the adequacy of justifications. Students may need to have their prejudices exposed. Values clarification can be an important goal of peer discussion if it is explicitly identified and practised by the teacher. The example thus shows that the epistemological issue of reliability can involve social aspects as trust, values and social custom.

There is also an additional lesson to be learned from this case. At first glance, it might look like the students' arguments are hardening, as they stick to their point of view in spite of the teacher's repeated challenge. Thus it looks like they are making a shift from a critical discussion, where all participants are committed to being open-minded, into an eristic dialogue, where arguments and views are fixed. However, although the teacher has a counterargument (the theoretical possible value is lower than the reported one), it is not provided to the students. The students consequently conclude that the burden of proof has not shifted and they do not see why they need to provide additional arguments. Based on their justifications they regarded the claim as trustworthy. This account of the dialogue exemplifies the importance of the teacher's awareness of the characteristics of a critical discussion when this is what she wants to facilitate.

However, does replicability automatically ensure that a result is reliable? Historically, scientific knowledge has, by definition, been regarded as neutral and objective (Ziman, 2000). However, today constructivist conceptions of science prevail and with them the principle that scientific knowledge claims are bounded by the cultural context in which they are generated. Thus results at the frontiers of science are not always readily accepted by the scientific community, as they can conflict with the expectations and beliefs of other scientists. How then, is science able to sort out which new concepts and models are valid and reliable? To explain the existence of reliable and uncontroversial scientific knowledge, many scholars point to the presence of social processes in science. These processes involve publication of research reports where arguments supporting a factual claim are presented; peer review prior to publication to evaluate whether the quality is sufficient, and critique of each other's hypothesis, methods and results (Ziman, 2000). Through these social processes some concepts or explanations become supported by a consensus within the relevant scientific community. Such consensus is believed to reflect the community's judgement of agreement between concepts and empirical data. Importantly, this image of science implies that argumentation and critical examination, including expert disagreement, is crucial for the development of scientific knowledge. However, it also implies that the reliability of scientific knowledge varies from controversial frontier science to consensual core science. This varying reliability represents a challenge for students' use of scientific research results in argumentation.

Students' Evaluation of Science Experts' Reliability

The arguments above indicate the need for activities through which students can explore the ways in which scientists validate and share their findings. Students may have naïve views about the generation of scientific truths. The question about the reliability of scientific knowledge claims is also reflected in students' handling of science involved in science-related issues. Students who have interpreted scientists' utterances and expert disagreement in terms of interests, integrity and possible incompetence have been reported in several studies (Driver et al., 1996; Gaskell, 1994; Kolstø, 2001a; Ratcliffe, 1999). Equally, some students have also been found to accept information from scientists without evaluation (Kolstø, 2001a; Ratcliffe, 1999). Teaching activities could usefully focus on clarifying, with students, criteria that might be used to judge the trustworthiness of the experts, in accordance with Walton's (1997) discussion of the issue. This implies a need to include a critical discussion on the reliability of the science expert when using arguments from experts.

Walton (1997, p. 211) states that the examination of experts' views need to focus on six crucial aspects related to the experts' claim to competence:

Is the utterance within the scientist's field of expertise?
Is the cited expert really an expert?
How authoritative is the expert? Is he, for example, recognised by colleagues as an outstanding expert?
If several scientists disagree on the matter, are several experts consulted?
Is supporting evidence available, and the utterance in accordance with this evidence?
Is the expert's utterance clear and intelligible, and correctly interpreted?

In addition, due to possible influence of vested interest and financially and institutional bindings, it is also necessary to judge the expert's personal reliability. This implies a focus on whether the expert scientist is biased, is honest, and is conscientious (Walton, 1997, p. 217). Consequently, social knowledge needs to be evoked in the evaluation of data used in arguments from experts (Bingle & Gaskell, 1994; Kolstø, 2001a; Norris, 1995).

The lists of questions above might leave the impression that if a scientist is found to be competent and personal reliable, then the scientific research results and judgements he or she contributes are neutral and objective knowledge. However, the question of the neutrality and objectivity of scientific knowledge claims is further complicated by the complex role of criteria and interest in science.

When evaluating scientific arguments, knowledge claims and competing theories, scientists are believed to use scientific criteria (Ziman, 2000). However, when not all criteria are fulfilled, and when the quality of evidence varies, different scientists might weigh criteria and arguments differently. Longino (1990) claims that in their evaluation of competing scientific theories, scientists' background assumptions influence their judgement. She argues that this is unavoidable due to the underdetermination of scientific theories by empirical data (for examples see Abd-El-Khalick, 2003; Kolstø et al., 2006). As shown in examples earlier in this chapter, students may come to similar biased views in their interpretation of arguments by peers and others.

The challenge associated with the application of scientific criteria implies that expert disagreement and argumentation are both legitimate and normal in science. This also supports the claim that the reliability of scientific knowledge depends on its ability to withstand criticism based on scientific norms and the strength of the consensus that supports it (Bingle & Gaskell, 1994; Ziman, 2000). Furthermore, Aikenhead (1994) claims that science has been undergoing a process of "socialisation" whereby "Government, industry, and the military have become the dominant patrons of scientific activity" (p. 16). Focussing on this and other changes, Ziman (2000) states that academic science has evolved into *post-academic science*. Today science is not only basic research practised at universities to fill gaps in a discipline's theoretical foundation. The typical scientist is not independent, but has become an employee or a contractor. The typical scientist thus works either in industry or governmental agencies, or has to make dispositions that might give him research contracts.

The question thus arises as to whether scientists' research agendas and judgement, and even interpretation of data, might be influenced by affiliation and vested interests. There are examples of how the asbestos, tobacco and oil industry managed to provide research which could be used as arguments against the claims that asbestos, smoking and lead in petrol represented risks to human health.

In addition it is important to be aware that "neutral" and reliable scientific knowledge might be produced according to a specific agenda, and functions to strengthen certain arguments in a dispute. The dilemma, which became apparent in the three industries above, is that some actors can better afford to initiate research projects likely to produce results which strengthen their own arguments. Moreover, Collingridge and Reeve (1986) argue that scientists involved in controversies tend to be more critical towards evidence supporting antagonists' arguments than towards evidence on which their own conclusions are based. For example, Geddis (1991) described the controversy between the United States and Canada on the source of acid rain. In this case, there was at first a lack of consensus on whether the evidence for the source of the acid rain was conclusive or not, due to difference in demands for certainty by each party.

The discussion above implies that trust in a science expert's competence and integrity is not sufficient. Claims from the frontiers of science (and in principle also consensual science), even though they are developed according to accepted standards, might be influenced by background assumptions, and the research questions might have been formulated, and funded, according to a specific agenda. Post-academic science is in general not separable from social needs and power relations because of the interactions between science and society.

A consequence of the above discussion is that the teaching of argumentation in relation to scientific issues needs to build on an awareness of social aspects of science. In a study by Kolstø et al. (2006) trainee science teachers were asked to judge the reliability of scientific claims in articles on the Internet related to a science-related issue. The participants were university students, and the study therefore indicates the relevance of different kinds of knowledge to those with deeper scientific insights than school students normally have. The study concludes that the students drew upon, among other things, their knowledge of possible interests of institutions providing scientific information, and also an appreciation of a source's critical attitude. In addition, they used their knowledge of how to recognise competence (relevance of education and current occupation) and an expert's prestige in science, academic standard of place of publication, and their awareness of the role and importance of consensus in science. Thus the knowledge base they used included more than scientific content knowledge. Evaluation of arguments based on expert authority is therefore demanding, as several aspects have to be taken into account.

School science can be portrayed, in textbooks and by science teachers, as authoritarian, without giving any insight into the supporting evidence. However, scientists' judgements are always made in social contexts, under conditions of underdetermination and influenced by background assumptions. A thoughtful evaluation of scientific claims, therefore presupposes a demand for, and an evaluation of, underpinning evidence and contextual aspects. In order for students to enter into evaluation of the reliability of expert utterances, it is essential that students realise that arguments from science experts are not always hard evidence. As with arguments from experts' authority in general, scientists' claims represent soft evidence as they have to be critically discussed in order to determine an argument's strength.

Consequently, it is important that the learning activities allows for inclusion of arguments from science experts, and at the same time stimulate critical discussions of the strength of these arguments. This conclusion is in accordance with Norris' (1995) judgement 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). However, in order for students' critical discussions to be thorough, some insight into the characteristics of post-academic science is a prerequisite. Social aspects of science therefore need to be included in school science.

Concluding Remarks

In this chapter we have emphasised that argumentation is a social activity and that arguments are used in different types of goal directed dialogues. Our focus has been to explore *how* some social aspects influence argumentation in scientific issues. We have discussed how dialogue in science classrooms has the potential to mirror argumentation in science as practised. We have focussed on how students' practices and conceptions impact on their possibility to participate in argumentation.

As a framework for the discussion, we have used Walton's (1998) concepts of dialogues and Toulmin's (1958) concept of arguments. We have clarified how scientific inquiry and critical discussion describe dialogue types used in science, and can also feature in some science classrooms. We believe that an increased awareness of these two types of dialogues has potential for improving the teaching of argumentation in science. Firstly, they may fulfil the two main goals for including argumentation in science teaching: the development of an understanding of the nature of science; the ability to consider socio-scientific issues thoughtfully. As science involves both collaborative development of arguments and critical scrutinising of knowledge claims, insight into the two types of dialogues implies an adequate image of science. Confronted with socio-scientific issues, students need skills in developing insight and argument, as well as the ability to ask critical questions of experts and to antagonists in dialogues. Secondly, the two types of dialogue provide conceptions of the contexts of argumentation, and thus a framework for purposeful design of teaching and learning activities. As indicated, scientific inquiry presupposes insight into the topic (or inclusion of information seeking dialogues), while critical discussion might be practised without specialised knowledge.

We have identified some specific challenges for the teaching of argumentation in students' construal of the rules and goals of the discussion in which arguments are embedded. Critical discussion might be weakened when students accept claims based on the arguer's charisma or other characteristics instead of critically scrutinising claims. In addition, the judgement of the relevance of arguments involves social aspects, and this is a challenge when the students dismiss arguments which do not support their egocentric values.

In our discussion, we have related arguments to their function in dialogues, and indicated that the social aspect of dialogues can facilitate the identification of social aspect of arguments. Using Toulmin's framework, we have specifically focussed on social aspects of claims and justifications.

We have claimed, on the one hand, that practices like the use of indistinct and flexible claims and arguments from experts' authority are legitimate under some conditions. On the other hand, we have claimed that some of students' practices and conceptions restrict their possibility to participate in thoughtful and rational argumentation. Examples here are the disputability of scientific knowledge claims and the importance of evaluating experts' reliability. Our discussions indicate that insight into the norms and social dimensions of science and the characteristics of post-academic science Ziman (2000) is a prerequisite for the analysis and the development of adequate arguments in science-related issues.

The complexity of the context of argumentation, involving: types of dialogues and goals, evaluation of experts' reliability, science(-)society interactions and students' interpretations of the purpose of different activities, indicates that a teacher's awareness of this complexity might be important for the development of students' learning. However, to support science teachers' use of argumentation, more insight into ways of facilitating the learning of argumentation in different types of dialogues is desirable.

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