ICT in Science Education

Exploring the Digital Learning Materials at viten.no

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Oslo October 10, 2005
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Summary

In this section I give a brief summary of the purpose, results and conclusions of the four papers in this thesis.

Paper I: *We know they love computers, but do they learn science? A study about the use of information technology and controversy in science instruction*

The purpose of this study was to investigate how the Viten program *Wolves in Norway* functioned in a classroom setting. The participants in this study are 59 students in two 9th grade classes from a culturally mixed school in a city of Norway. We asked the following research questions:

- *What learning gains were achieved related to the biology of wolves, ecological management and the controversial issue of wolves in Norway?*
- *To what extent did this learning influence the students view on wolves?*
- *Were there any differences in the responses of girls and boys?*

Our results show that there is a qualitative difference in the students' answers to open-ended questions before and after the work with *Wolves in Norway:* the posttest answers are more specific, containing examples, claims are often backed up by reason, and the students are using biological concepts like predator, prey, population and rabies in contrast to the more general pretest answers that are often dressed in an emotional language.

Wolves in Norway did change the ways students are thinking about the danger of wolves with 2/3 of the students changing their opinion about the issue. Our results show that all the students who claimed that wolves are dangerous at the pretest actually have changed their view to *dangerous under specific circumstances* at the posttest and follow-up. Common traits in students' answers indicate that they refer to two particular units in *Wolves in Norway*; one is a summary of a research report on the danger of wolves, and the other

providing graphical information on loss of livestock due to large predators. These had the strongest influence on student opinions regarding this issue. Our results are also in line with recent surveys on peoples' attitudes towards wolves in Norway, reporting that people with confidence in scientific knowledge are likely to be more positive towards wolves than other people (Bjerke, Skogen, & Kaltenborn, 2002).

Girls in this study spent more time on *Wolves in Norway*, also scoring higher on posttest and delayed posttest, indicating that students when spending more time on the different activities absorb more of the content and also have a higher degree of retention. Of course the sample size in this study is too small to draw conclusions. However, the result is interesting in light of findings in Program for International Student Assessment (PISA), which show that of all participating countries, Norway has the second largest gender difference in reading competences in favour of girls (Lie, Kjærnsli, Roe, & Turmo, 2001; Kjærnsli, Lie, Olsen, Roe, & Turmo, 2004). If it is so that girls are better readers, spend more time on task and score higher on performance tests, this is important information for teachers and program developers. It would be interesting to follow-up these results more systematically in a study with a larger sample.

Furthermore, results and experiences from this study have resulted in revisions of *Wolves in Norway*. For instance, information about laws and international agreements is made more accessible in the program and names of regional areas are provided on the map where students should mark wolf areas in Norway.

Paper II: *A Case Study of Design and Implementation of the Web-based Viten Program Radioactivity*

Paper II provides an example of a Viten program investigating scientific phenomena. The phenomenon in focus is radioactivity, which is a traditional topic in science education in secondary schools across the world. The Viten program *Radioactivity* has a novel approach to traditional content, in terms of a context where students have roles as journalists and a mission to solve. I ask the following research questions:

- *What features of Radioactivity are likely to have an impact on student learning?*
- *What are students actually learning when using the Viten Radioactivity program?*
- *What are student's opinions about the Viten Radioactivity program?*

The students improved their knowledge on radioactivity and when they were asked to give their opinion about the program, they had more positive than negative comments. The categories identified when summarising students positive comments provide some general signals about what students appreciate in a teaching sequence: using computers, variation, informative materials, working together, student control. These are key words to have in mind when planning any teaching sequence or developing new learning materials. In addition many students enjoyed the design and pedagogical arrangements in *Radioactivity*, solving a case, and they thought it was easier to learn because of the animations and visualisations.

The strength of *Radioactivity* is the part focusing on radioactivity as a phenomenon, and the way it is presented. Interactive animations and other remedies contribute to student learning by making the invisible visible. There is a high degree of accordance between the animations in *Radioactivity* and guidelines for animations found in the research literature (e.g. Rieber, 1991; Milheim, 1993); they are simple with no unnecessary text or features, they are designed as several steps where students can manoeuvre back and forth and they are related to important and invisible phenomena like the three radiation types. Features of animations are reflected in some student answers, both in the form of text and drawings. It would strengthen *Radioactivity* if the experiences from developing animations, interactive and written tasks regarding radioactivity as a phenomenon could be used to develop animations on radioactivity as a threat and as a resource, for instance on how ionising radiation is used for medical purposes or the effect and presence of radon in peoples houses.

One weakness of the study is that the students were not able to complete the work on *Radioactivity*. The developers of Viten had estimated from four to six class periods to complete the program, and the teachers involved decided to use four class periods. It turned out that this was not enough, and for several reasons it was not possible to find extra time. In contrast to controlled experiments, it is not possible to predict what happens when one conducts studies in real classrooms. Most students therefore did not complete the task of writing a newspaper article with scientific content. This is a time consuming and demanding task, where students often revisit units in the program during their production of text for the newspaper article. I strongly believe that such tasks influence student learning outcome but in the case of the present study, we will never now… Almost half the students mentioned that they disliked the fact that they were not able to complete the program, a clear indication that they enjoyed working on *Radioactivity*.

Paper III: *A dual approach to analysing student argumentation in classroom debates*

The main purpose of this study was to investigate how the Viten learning materials are able to mediate science content, thus finding a fruitful way to analyse student discourse following from the work with *Wolves in Norway.* Through the use of role-play debates students were provided opportunities to apply information from *Wolves in Norway* in an authentic context. Investigating student discourse and argumentation provides important information about students' appropriation of information provided in *Wolves in Norway.* The most commonly used frameworks for analysing argumentation in science education research focus on the structure of argument rather than its content. I believe that one must focus on both. Hence, to analyse the discourse in the present role-play debates, I developed a novel approach that considers both structure and content of arguments. The following research questions are asked:

- *What is the content of students' argumentation?*
- *How does structure relate to content in students' argumentation?*

My contribution to the field of science education from this study is a dual approach to analysing argumentation that takes both structure and content into account. The dual approach functioned well as a tool for analysing student utterances and shows that student arguments varied from simple claims, to more elaborated arguments where reasons for claims were backed up by evidence and comparisons or examples. The most elaborated arguments also seem to be associated with correct content however, correct content is also found in less complex arguments. The majority of the utterances in this study contain correct or partly correct content, and students draw on biological, personal/social, political and economic information in their arguments.

Wolves in Norway seems to serve as a good tool for facilitating discourse and argumentation in role-play debates. The program provides information on biological topics and environmental management issues, as well as information on the viewpoints of different interest groups in the conflict. The role-play debate context seems to be a good arena for talking science and students are clever at constructing arguments and refuting other students' arguments.

An interesting further line of research would be to apply this approach to various types of classroom debates with the view of comparing the profiles of debate types. For instance: Are there any differences in outcome of debates that are aiming at consensus as compared to a more competitive debate context like the present? Another potential line could be to compare role-play debates with more traditional classroom debates.

Results from this study have lead to some revisions of *Wolves in Norway*. More explicit information about the formal structure of arguments is included, and the role-play debate activity is further developed and included as a closing activity in the more recent Viten programs *Bears* and *Gene-technology.*

Paper IV: *Argumentation in science lessons: Focusing on the teacher role*

Even though argumentation is regarded as an educational goal in science education, activities involving argumentation are not common in science lessons. It has been suggested that one important reason for this is connected to the role of the teacher. Thus in this paper I focus on the role of the teacher in the same role-play debates that are studied in paper III. My research questions are the following:

- *What are the reasons for teacher interventions in managing the debates?*
- *What types of interventions are used by the teacher to manage the debates?*

In the role-play debates I identified six main reasons for teacher interventions that are related to: accuracy of content, narrow range of topic, debate off track, coming to a stop, level of participation and maintaining order of speakers. Each reason prompted some sort of action from the teacher, and these actions are characterised as: challenging the correctness of content, extending the range of a topic, getting the debate back on track, keeping the debate alive, involving more students and focusing on debate technique. The main contribution of this paper is the development of a typology, including teacher interventions and reasons of a general character that may serve as a useful tool for student teachers and teachers in managing classroom debates regardless of issue. Given the research evidence that teacher practice improves when they are empowered by reflection and understanding on their teaching actions, such insight would help create powerful strategies for more effective implementation of traditionally unfamiliar discourse forms such as argumentation (Erduran, Simon, & Osborne, 2004).

List of papers

Paper I: Mork, S. M., and Jorde, D. (2004). We know they love computers, but do they learn science? A study about the use of information technology and controversy in science instruction. Published in Themes in Education, 5(1), 69-100

Paper II: Mork, S. M.: A Case Study of Design and Implementation of the Web-based Viten Program *Radioactivity.* Manuscript

Paper III: Mork, S. M.: A dual approach to analysing student argumentation in classroom debates. In review for Science Education

Paper IV: Mork, S. M. (2005). Argumentation in science lessons: Focusing on the teacher role. Published in Nordic Studies in Science Education, 1(1), 16-29

Appendices

Appendix 1: Information letter to students and parents

Appendix 2: Data analyses for paper III and IV

1 Introduction

Information and communication technology (ICT) has evolved to become a natural part of people's lives in modern western information societies, where the Internet for instance is used to read newspapers, pay bills, keep in touch with friends and search for information for private and professional purposes. The enormous information flow available to the public, places high demands on people's skills in being critical to information and various information sources. Science pervades many contemporary issues, not only in the form of core science[1], but also frontier science[2]. Hence, ability to evaluate information with a science dimension for instance in terms of: Consistency between claims, reasons and evidence, the sample sizes when researchers are testing new medicines, calculation of risks when building nuclear power plants etc, is important and must be addressed in science education.

Furthermore, ICT has in many ways become a powerful tool that has revolutionised the work of scientists. It is now possible to handle larger amounts of data, and more complex models and simulations can be developed and tested. The communication processes within the scientific community are speeded up because of easier access to research results in online scientific journals, and with access to the Internet, it is easier to collaborate with fellow researches across geographical boundaries. These changes in the work of scientists should to a certain degree be reflected in science education.

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[1] Core science is characterised by a stable consensus within the scientific community. This is science were the disputes, at the initial stages of the research, have been settled, and now appears as facts in textbooks (Kolstø, Bungum, Arnesen, Isnes, Kristensen et al., submitted).

[2] Frontier science is science in the process of being researched. At this stage of the production of scientific knowledge, hypothesis are being developed and scrutinised, and results from studies are presented to colleagues and discussed. Subjective and unreliable frontier science is transformed into core science, or refused as not reliable, through different social processes characterised by publication, evaluation and argument (Kolstø et al., submitted).

At the educational level, research on the potential benefits of ICT follows naturally from considerable investments in hardware, software and infrastructure along with development of teachers' competence. ICT has been regarded as an interesting force for pedagogical change. The advent of ICT, and its more widespread access in schools, potentially has an important part to play in re-shaping the curriculum and pedagogy of science (Osborne & Hennessy, 2003). ICT offers easy access to a vast array of Internet resources and other new tools and resources that facilitate and extend opportunities for empirical inquiry[3] both inside and outside the classroom (ibid). Furthermore ICT may also serve as a tool facilitating collaborative learning and discourse among peers, and providing information bases for classroom debates. Several scholars have studied learning environments[4] where students abilities to use knowledge as part of arguments and discussions have been facilitated (Brown, 1992; Scardamalia & Bereiter, 1996; Arnseth, 2004). Ideas informing the development of these environments are founded on research which has demonstrated that students learn best when they are able to engage in discussions where ideas are made available for mutual inspection and reflection (Rogoff, 1990). Socioscientific issues[5] are often used as a means for students to practice argumentation skills (e.g. Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Zohar & Nemet, 2002; Sadler, 2004). Hence, it has been suggested that introducing contemporary socioscientific issues to science teaching may make science more relevant to students' everyday life, and at the same time provide a more realistic picture of the nature of science; its strengths and limitations. However, many teachers find it difficult to teach about such issues, as they are uncertain in nature, work demanding to prepare and conduct, and often involve ethical and social dimensions. The main topic of this thesis concerns how ICT in form of digital teaching programs may serve

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[3] By definition, inquiry is the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments (Linn, Davis, & Bell, 2004).

[4] Learning environments consist of a coherent curriculum and a suite of technologies to support teachers and students in learning, instruction and assessment (Linn, Davis et al., 2004).

[5] By definition, socioscientific issues involve scientific claims and arguments, in addition to the political, personal or ethical questions of what action to choose. Moreover, in many socioscientific issues, central scientific claims are also disputed (Kolstø et al., submitted).

as a vehicle guiding students and teachers in exploring socioscientific issues and scientific phenomena.

As a means to focus on ICT in science education, I explore the digital learning materials developed by the Viten[6] project. Viten is a Norwegian research and development project (Jorde, Strømme, Sørborg, Erlien, & Mork, 2003) providing a web-based platform with digital learning resources[7] in science for secondary school. The digital learning materials are available for free, and no additional software is needed to use them. Students in grade 8-12 can work collaboratively on various science topics and each topic ranges in duration from 2-8 science lessons. Three types of programs are available, that engage students in: a) designing solution to problems, e.g. design a greenhouse for growing plants in a spaceship on its way to Mars, b) debating controversial issues, e.g. whether or not there should be wolves in the Norwegian wilderness, c) investigating scientific phenomena, e.g. radioactivity, gene-technology. Since launching the web-site viten.no with three teaching programs in the winter of 2002, 14 teaching programs are available in June 2005, see Table 1.1.

Data from the Viten server shows that 1853 unique teachers have run at least one Viten program in one or more science classes as of June 22, 2005, and that 63 083 unique students have answered at least one task in one or more Viten programs in the same period. Hence, the total number of registered student users reported in Table 1.1 illustrates that many students have used several Viten programs[8].

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[6] The word **Viten** means **knowledge** in Norwegian.

[7] In *Program for Digital competence,* digital learning resources are defined as pedagogical tools that can be used for learning purposes, and that exploit ICT in promoting learning via products, services and processes (UFD, 2004a).

[8] It must be noted that there could be some sources of error related to the numbers in Table 1, for instance, that students register but do not work through the program or that teachers testing the program register a test student. However, we also know that some teachers let their students use demo-versions, and these users are not counted.

Table 1.1: *Overview of the available Viten programs and corresponding number of registered student users by June 22, 2005.*

Year	Program (Launched)	Student users by June 22, 2005
2002	Radioactivity (January)	25 586
	Wolves in Norway (February)	6 810
	Cycles of malaria (March)	4 508
	Sine-waves (August)	1 095
	Plants in space (September)	5 437
2003	Earth processes (January)	9 207
	Bears (March)	2 411
	Hydrogen as energy source (August)	5 008
	Gene-Technology (December)	24 102
2004	Cloning (August)	1 749
	Cloning of plants (August)	956
	Health up in smoke (August)	4 756
2005	Climate changes in the Arctic (February)	2 007
	Dinosaurs and fossils (April)	1 151
	Total	**94 783***

**This number does not represent unique student users, as some students have used more than one Viten program. To be counted as a student user of a Viten program; one must first get access to a registration code from the teacher and then use a program activated by the teacher.*

The Viten project is a collaboration between the University of Oslo, the Norwegian University for Science and Technology and the Norwegian Centre for Science Education. Viten is well established within schools, as illustrated by the high number of users in Table 1.1. Viten has at several occasions been put forth as one of the good examples of digital learning resources in the Norwegian context. The translation of several Viten teaching programs into Danish, Swedish and English, and the fact that Viten has been awarded two prizes in 2005[9] confirm that the Viten digital learning resources have a good reputation.

[9] The Viten project has been awarded two prizes in 2005: In May 2005 the Viten program *Gene-Technology* received the Norwegian e-learning prize, where the jury emphasized: "*The high quality of content, connections to the national curriculum, user-friendliness and universal design makes the program accessible for the target group. The broad spectre of activities stimulates increased and differentiated learning. With its design and content the program inspires to development of new digital learning resources*". In June 2005 Professor Doris Jorde, on behalf of the Viten team, was awarded the University of Oslo's communication prize: *"The University of Oslo's prize for good communication of research is awarded to a researcher or a research group that has communicated research-based insight that has triggered interest in the target groups – narrow target groups as well as a broader public"*.

Crosier et al. (2002), suggest that school-based evaluation studies are important for gaining an understanding of how software will be used and integrated in school settings. They further argue that observing students using the software and gathering their opinions of it will ensure to which extent the software is useful, enjoyable and usable by students, in addition to the educational goals being satisfied. Many curriculum innovations are introduced into science classrooms as a part of research and developments projects (e.g. Furberg & Berge, 2003; Jorde et al., 2003; Linn, Clark, & Slotta, 2003; Songer, Lee, & McDonald, 2003; Squire, MaKinster, Barnett, Luehmann, & Barab, 2003). A side effect of the design research process is that researchers sometimes create environments that are not applicable to larger, everyday contexts of schooling (Fishman & Krajcik, 2003). Fishman & Krajcik argue that too frequently, following the initial research on an innovation, researchers leave unexamined future implementation, which is treated as "just implication", something that happens after real research. They therefore advertise for studies investigating further implementation, and identifying the characteristics of innovations that are needed for developing sustainable curricula. In light of the many users of Viten programs, and the translations to other languages, it seems appropriate to address features of the Viten learning materials and what impact they may have on science learning.

1.1 Research questions

The development of digital learning materials like Viten programs is based on various theoretical perspectives on learning, knowledge about the subject in focus, experiences from classroom research and teaching. Even though development of digital learning materials has been going on for some time, such materials are still not commonly used in Norwegian schools. Hence studying the implementation of digital learning materials in ordinary classrooms may yield insights into the potential advantages or disadvantages of such materials, and how they are employed for educational purposes. There is a tendency amongst teachers when implementing new learning materials, digital or other; to reframing innovations to recreate familiar practices. At the same time many teachers are eager to learn new ways of approaching issues in various disciplines. This study seeks to investigate how digital learning materials from the Viten project can be employed in Norwegian lower secondary science classrooms. I will address various features of the learning materials, their effectiveness and the way in which these materials can facilitate classroom discourse.

- *What are the characteristics of digital learning materials from the Viten project, and how do they influence science learning?*
- *How are the digital learning materials from the Viten project able to serve as vehicles to facilitate students' ability to use knowledge as a part of argument and discussion?*

The first research question is addressed in paper I and II, while the second research question is addressed in paper III and IV.

1.2 My motivation for this study

My work on this thesis is influenced by my background as a science and ICT teacher at a lower secondary school My former school had a profile of being in front regarding ICT in the 1990s, as coordinators of, and participants in several Comenius projects involving ICT, and providing compulsory 40-hour courses in the basics of ICT for all 8th graders in the school from 1997. I was part of a group of enthusiastic teachers experimenting with pedagogical use of ICT. ICT was a new tool for us, and we were desperate for new impulses and tips on how to exploit the potential of this tool in our teaching.

My main motivation for becoming involved in this research project was to investigate the potential that lies in digital learning materials like Viten programs. The learning resources from Viten are quite unique in the Norwegian context. Attempts have been made to develop digital learning resources in science (e.g. Furberg & Berge, 2003; Wasson & Ludvigsen, 2003), and other subjects, however some of these require some specific software and have not been made available to schools in general. Viten programs are widely used by Norwegian students and teachers; hence information on experiences from using these digital learning materials may provide important insights on the function of such materials and hopefully make a contribution to the field of science education.

1.3 Outline of the thesis

In chapter 2, I first give a brief introduction to the emergence of ICT in education, before focusing on the implementation of ICT in the Norwegian educational system I conduct a review of policy documents regarding ICT in primary and secondary education, and some of the main studies mapping the digital state in Norway.

In the next section, research paradigms in ICT are briefly described, followed by a paragraph on ICT and the social construction of knowledge where I draw on social constructivism and a sociocultural perspective on learning. Language is central in a sociocultural perspective on learning, moreover language and argumentation are central to this thesis and are described in section 2.5.

ICT in science education is introduced in section 2.6, followed by descriptions of Viten and an outline of my role in Viten.

The four papers included in this thesis are introduced in chapter 4. Some methodological concerns are included in the introductions to the papers. I use different methods in my four papers; hence the methodology is described in each paper.

2 Setting the scene

In this section I briefly introduce ICT in education, before focusing on the emergence of ICT in the Norwegian educational context.

2.1 Emergence of ICT in education

ICT has a relatively short history in the educational system, but its history and current status are important to understand how they influence teaching and learning. From the first introductions of ICT in schools, the view of ICT has swayed between unlimited faith in technology as a vehicle for revolutionising learning, to scepticism about the promises of such developments (Light, 1997; Säljö, 1999). Schofield (1995), argues that in contrast to earlier technological innovations like TV and video, ICT has some important features that may have a major impact on schools: ICT is interactive and can be used to accomplish extremely varied purposes, from editing text to providing simulations of dangerous or expensive laboratory equipment, to putting students in direct contact with others from around the world.

Many western countries have invested large sums to implement ICT in the educational system. The Norwegian government has invested more than a billion Norwegian crowns during the last decade for educational purposes. Edelson (2001), argues that computers in many cases are being installed without a plan for how to integrate them into the curriculum. It seems to have been a common conception that if ICT is introduced into classrooms, changes will eventually come about (e.g. Krumsvik, 2004). Nevertheless, so far the outcome of these investments has not always been satisfactory. Frønes (2002) suggests that if the speed of technological development is very high, cultural delays may occur, i.e. that cultural or institutional patterns do not grasp the new sense of the technology. Institutions like schools often change slowly, since established norms have a tendency to survive attempts to change. Schools have their own cultures that need to be understood before implementing new uses for ICT successfully. Knowledge about and understanding of pedagogy, subject content, and the school as an institution, are all necessary before significant changes due to the introduction of ICT are likely to occur. Säljö (1999) suggests that it would seem appropriate to inquire more precisely into what features of ICT are likely to have an impact on learning in the diverse range of settings in which people appropriate knowledge and skills. The issue may not just be one of facilitating teaching and learning as we conceive of these processes today. It may also be that what we conceive of as learning will be somewhat different when our communicative practices change (ibid).

2.2 The digital state in Norway

The use of ICT[10] in schools has been on the political agenda in Norway since the mid 1980s. As expected when implementing technological innovations, in the beginning the focus was on purchasing and installing equipment and learning how to use it. When evaluating the action program for ICT in schools in the period 1984-1988, Dalin and Stranden (1989) point to material resources as computers, competence among teachers and teacher and student attitudes, as the most central conditions necessary for increasing the use of ICT in schools. In an international perspective, Norwegian schools have had good access to ICT since the late 1990s (e.g. Quale, 2000; UNDP, 2001; Frønes, 2002; UFD, 2005). In 2005 there is a mean of 6.5 students per computer in primary and lower secondary schools, while the corresponding mean in upper secondary schools is 2.5. However, it must be noted that there are large differences between schools. An increasing number of computers are connected to the Internet however some primary and lower secondary schools are still without Internet access and less than 40% of schools have a band width of 2 Mbit/s or more (UFD, 2005). The number of computers found in schools does not say anything about their quality. Computers may be quite old, since many schools do not have the economy to invest in updated equipment. This situation contributes to another challenge for many schools:

[10] The Ministry of Education originally used the notion information technology (IT) in governmental reports and plans, but from around the late 1990s, this term is gradually replaced by information and communication technology (ICT). To avoid confusion, in this thesis I choose to consequently use the term ICT.

support and maintenance of networks and computers. Many schools do not have personnel with technological competence to deal with ICT-related problems, and when the machine park consists of several generations of computers, it is more unstable and demanding to keep going.

In 1994, the Ministry of Education, Research and Church Affairs (KUF, 1994) realised that it was time to move further, and suggested that ICT should be integrated as a tool in the syllabi for all subjects where this was natural, and at all levels of the educational system. ICT as a specific subject should still be offered for those interested. The government put forth an action plan: *IT in Norwegian Education - A Plan for 1996-1999* (KUF, 1996a) with the ambition that Norwegian students and teachers at all educational levels should become personal users of information technology in the sense that they are able to use information technology in their learning process and form a basis for using it in future professional and private life. To reach this aim, information technology should be integrated as a tool supporting the nature of each subject, to increase understanding and motivation. In the same period, a new national curriculum for primary and secondary school was implemented (KUF, 1996b), which explicitly stated that ICT should be used in the teaching of virtually all subjects. However, the curriculum and textbooks gave few guidelines about pedagogical uses of ICT. No wonder many teachers felt frustrated when asked to use a new tool without knowing exactly what to do with it.

In 1997, the Network for ICT Research and Competence in Education (ITU) was founded by the Ministry of Education and Research, with a mandate to contribute to national knowledge building[11] about digital education and digital skills, and be an innovative national research and development unit in the field of ICT and education. ITU has served an important function in putting ICT on the agenda and fostering innovation in the academic and pedagogical use of ICT in learning and education. Through initiating a number of ICT-

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[11] According to Scardamalia and Bereiter (1996) knowledge building means that knowledge is actively constructed and made available for inspection in a community, something which require that participants in such learning communities adapt to the gradually evolving knowledge of the community.

based projects (e.g. Ludvigsen & Østerud, 2000; Dons & Bakken, 2003; Furberg & Berge, 2003; Jorde et al., 2003; Wasson & Ludvigsen, 2003; Erstad, 2004; Krumsvik, 2004), ITU has contributed to the development of a national knowledge base relating to the development of digital education and digital skills. ITU also arranges a yearly conference that gathers teachers, researchers and policy makers within the field of ICT, and serves as an important arena for exchanging ideas and experiences. However, there seems to be a gap between the pilot projects and innovations funded by ITU on the one hand, and general ICT practice in Norwegian schools on the other, as reported in e.g. *ITU-Monitor 2003* (Kløvstad & Kristiansen, 2004). Nevertheless, it is of major importance that institutions like ITU can be in the forefront of technological developments, providing examples and guiding the development and implementation of ICT in general.

In the White Paper; *Culture for learning* (UFD, 2004b), the Ministry of Education and Research introduced five basic skills that they consider as fundamental for being able to acquire and develop knowledge in various subjects, but also form the basis for being able to communicate and interact with other people in a broad range of relations. These skills are: being able to express oneself orally, being able to read, being able to express oneself in writing, being able to do arithmetic and being able to use information and communication technology. Hence, digital competence is now considered as equally important as reading and writing; a major recognition for education. The Ministry of Education and Research further suggests that in order to make sure the pupils continuously develop their basic skills throughout their school years, developing these skills must be integrated into the syllabi for all subjects at all levels. This ambition is also embedded in the new Norwegian national curriculum *Knowledge promotion* (Utdanningsdirektoratet, 2005) [12].

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[12] In the new national curriculum *Knowledge promotion,* basic skills are embedded and defined in the syllabi for each subject. Digital skills in science means *"to be able to use digital tools to explore, measure, visualise, simulate, register, document and publish from experiments and fieldwork. To stimulate creativity, and visualise scientific issues, digital animations, simulations and games are good tools. Critical evaluation of web-based scientific information strengthens the work in science. The digital communication systems offer opportunities to discuss scientific issues"* (My translation).

Integrating ICT in the syllabi for all subjects is exactly what was suggested 10 years ago (KUF, 1994). One may therefore think that this is no longer an issue. However, results from the first year of a longitudinal study concerning the digital state of Norwegian schools: *ITU-Monitor 2003* (Kløvstad & Kristiansen, 2004), indicate that in general, computers are very seldom used, and they are not adequately integrated in each subject. The limited use of computers in schools reported in *ITU-Monitor 2003* is disappointing since it also confirms the results from another study in 1998/99 (Quale, 2000), indicating that not much has happened regarding the use of ICT in schools during this five year period. According to Kløvstad and Kristiansen (2004), only a few applications and services are used, most commonly word processors and searching for information on the Internet.

The TIMSS study (Grønmo, Bergem, Kjærnsli, Lie, & Turmo, 2004) also confirm that searching for information on the Internet is the most commonly used activity involving ICT in Norwegian science lessons, despite the fact that there is adequate access to computers. Thus the authors argue that there seems to be a great potential for exploiting the available equipment. It must be noted that there is a tendency of broader and more extensive use of computers in upper secondary schools, as compared to lower secondary and primary schools (Kløvstad & Kristiansen, 2004). Preliminary results from *ITU-Monitor 2005* (Erstad, Kløvstad, Kristiansen, & Søby, 2005) show that students in grade 13 spend much more time at the computer now, than two years ago. At the same time, there has been little development in the use of ICT in lower secondary school (ibid).

But overall, it seems like the goals and intentions in policy documents are followed up only by a few innovative schools. Hence, including digital competence in basic skills may contribute to bridging the gap between the general state in schools, innovative schools and goals in policy documents.

Kløvstad and Kristiansen (2004) further report that there are few gender differences in use of computers, both among students and teachers. Moreover, teachers basically use computers in their preparations for teaching, while students mostly use computers in project work; most commonly searching the Internet for information, and using a word processor and/or presentation program to report their findings. Many teachers seem insecure about how to implement ICT as a natural part of their teaching. The ICT competence of teachers is crucial for the integration of such tools in teaching and learning. The ICT competence among Norwegian teachers is variable, even though most teachers are offered the opportunity for in-service courses (For instance, 18 000 teachers were enrolled in LærerIKT[13] from 2001-2004). LærerIKT is a web-based in-service education, commissioned by The Ministry of Education and Research, focusing on competence building in the educational use of ICT. An evaluation of this course shows that teachers use ICT more frequently than before, but mainly in preparation for teaching (Alfredsen & Jamissen, 2003). This is as expected since LærerIKT focuses mainly on basic skills like word processing, search on the Internet and presentation programs.

ITU-Monitor 2003 also reveals that most teachers and students evaluate their own knowledge about computers as good, and think they have good skills in using the Internet, e-mail and word processor. The majority of students have access to better computers at home than at school. About 50% of the students prefer to do school work at the computer at home, and they conduct more complex and advanced operations at home than at school (Kløvstad & Kristiansen, 2004). These findings illustrate how ICT is naturally integrated in most students' everyday life, and the paradox that many schools are not able to follow up this trend.

In 2004, the Ministry of Education and Research put forward the new five-year *Program for digital competency*[14] (UFD, 2004a), emphasising the following two challenges:

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[13] http://www.larerikt.no/info/english_english_hoved.html

[14] Digital competency is here defined as the competence that bridges skills like reading, writing, being able to do arithmetic, and the competence that is needed to be able to use new digital tools and media in a creative and critical way (UFD 2004a).

- *ICT must be better integrated in teaching and learning than today. This requires a better balance between the access to technology and the actual use of new technology. It is a major task for future education that digital competence is included as a natural and everyday part of teaching and learning at all levels of the educational system. ICT must no longer be a case for those who are particularly interested.*
- *It is necessary to show/expose the success factors, bottle necks and good examples for the educational sector.*

To meet these challenges, *Program for digital competency* suggests prioritizing the following four areas: a) infrastructure, b) development of digital competence, c) development of digital learning resources, curriculum and work forms, and d) research and development. The Ministry of Education and Research actually states that by 2008, all learners should be able to use ICT in a confident and creative way to develop the knowledge and skills they need for participating in a democratic society. Another ambition is that the Norwegian educational system should be among the best in world regarding development and pedagogical use of ICT in teaching and learning (ibid). The prioritising of the four areas mentioned above is important, especially the focus on development of digital learning resources. To face the challenge of promoting integration of ICT in the syllabi of each subject, teachers should have a range of digital learning resources to choose from. Even though there are idealistic individual teachers developing web-based learning resources on their own and using ICT creatively in their teaching, it is unrealistic to expect all teachers to do so. Hence, access to a variety of digital learning resources can motivate teachers to integrate ICT in their teaching, and hopefully promote a more creative pedagogical use of such resources. Likewise, good infrastructure is of major importance for pedagogical use of ICT since many ICT applications, like downloading of film/video, production and distribution of film/video, three dimensional simulations, the use of games, teaching via web-camera or video conferences, require broad band (Kristiansen, Grøndahl, Jorde, Kvingedal, Melve et al., 2003).

2.2.1 Digital competence

As mentioned above, digital competence is placed on the agenda by *Program for digital competence* (UFD, 2004a) and the White Paper *Culture for learning* (UFD, 2004b). Digital competence is a complex concept; consequently there exists a broad range of definitions. ITU has taken the initiative for a report describing and defining digital competence with a focus directed towards the following four dimensions[15]:

Dimension 1: Skills in using ICT

In most western countries, courses regarding use of computers and computer programs, often denoted as "ICT driving license", have been offered. These have traditionally focused on improving skills. In recent years all the Scandinavian countries have included the need to adjust the skills to teachers' actual use in the classroom and the contextual issues pedagogical use of ICT must take into account. In this lays also a perspective on ICT as a field of knowledge, i.e. knowledge about the technology itself. As a part of this one must also include a progression emphasising what skills one expects students to possess at various stages of the educational system, and how this relates to the use of ICT outside school. Technology changes over time: so will also appropriate ICT skills.

Dimension 2: ICT and the knowledge domain of each subject

ICT partly influences the changing premises for the traditional activities in school, as reading, writing and arithmetic. New premises are created in the form of options for simulations in e.g. physics and chemistry; the possibility to communicate with others outside schools, and the access to information through the Internet. Digital competence is therefore also an expression of the professional use of ICT and how this challenges the basis of knowledge in various professional settings. In this lays also the considerations of how student "higher order thinking" is stimulated and developed.

[15] http://www.itu.no/digital_kompetanse/index_html

Dimension 3: ICT and learning strategies

This involves cross curricular competences. A basic issue is how students orient themselves regarding information flow as represented by the digital technology, how they reflect and are critical to sources and information in pedagogical connections, and what relation they have to the communicational aspect of technology. For students this implies skills in learning and learning by the use of ICT. In this connection it will also be natural to take a closer look at the relation between different learning arenas, and the relation between the formal and informal learning.

Dimension 4: ICT and the cultural competence

This dimension is defined as a broader cultural competence compared to the previous, and therefore harder to specify. It involves functioning optimally in the knowledge society and being able to consider the technological frames influencing our culture. One could say that this dimension goes across the previous ones and is integrated in these. Digital literacy is an expression for a total understanding of how young people learn and how they develop their identity. In addition the concept also includes how skills, qualification and knowledge are used in the culture. Digital literacy points to an integrated approach that enables reflection around the influence of ICT on various qualifications like communicative competence, social competence, students' critical attitudes and so on[16].

Based on the four dimensions above, the report defines digital competence broadly to include the fact that digital competence is about more than basic ICT skills (ITU, 2005). It is necessary that young people master such competence to navigate safely and constructive in a digital world. Hence the definition is:

> *"Digital competence is skills, knowledge, creativity and attitudes that everybody needs to be able to use digital media for learning and command in the knowledge society"*

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[16] The four dimensions are translated by the author.

The group behind the report provides eight recommendations for promoting digital competence. One of these concerns digital learning resources, and they state that digital content is an important driving force for use of technology in an ICT-based learning environment. They further argue that to be able to meet the goals of developing digital competence as a basic skill in the new national curriculum, students and teachers need considerably better access to digital tools and digital learning resources (ibid).

2.2.2 Examples of ICT studies in the Norwegian context

The Viten project is of course an example from the Norwegian context; further descriptions follow in section 2.8, and in the four papers of this thesis.

Project Innovation in Learning, Organisation and Technology (PILOT)[17] has been Norway's largest and most extensive innovation project in proximity to pedagogical aspects of the implementation of ICT in schools (Erstad, 2004). The paramount objective was to allow participating schools to develop the pedagogical and organisational contingencies that use of ICT in teaching affords. 120 schools were involved in the project from 1999 – 2003. The main conclusion from the project is that schools working systematically with organisational settings, flexible methods and focus on learning are most successful in the use of ICT (ibid). PILOT consists of an entire range of sub-projects, and conclusions from these are among other factors that when using ICT, student learning outcomes increase, ICT challenges the nature of each school subject, students and teachers are using ICT differently, text production increases when using ICT, there are positive results from using ICT in initial training of reading and writing, and the importance of teachers' professionalism and subject knowledge increases when using ICT (ibid).

[17] http://www.itu.no/Prosjekter/t1001943024_4/view

Another Norwegian ICT project is the Design and use of Collaborative Telelearning Artefacts (DoCTA), a multidisciplinary research project aiming at bringing a theoretical perspective to the design of ICT that supports the sociocultural aspects of human interaction, and to evaluate its use. DoCTA provided and studied virtual learning environments that where deployed to students organised in geographically distributed teams. Various scenarios utilising the Internet were used to engage students in collaborative learning activities on for instance Gene-Technology. Results from the DoCTA project indicate that too few students use higher order skills as part of their learning activities, confirming discoveries in many international studies (Wasson & Ludvigsen, 2003). Wasson and Ludvigsen report that students and teachers have a tendency to place more importance on solving the task than on the domain of concepts to be learned, suggesting that students need to employ higher order skills when dealing with knowledge building in complex and conceptually-oriented environments in order to go beyond fact finding. Another observation from DoCTA is that the teacher is extremely important in supporting, stimulating and motivating the students to integrate previous knowledge with the new information they encounter (ibid).

The last example mentioned here is the Second Information Technology in Education Study: Module 2 (SITES M2). This is an international qualitative study of innovative pedagogical practices that use ICT. SITES M2 involved 174 selected case studies from 28 countries, whereof 11 were Norwegian. Most of the case studies are embedded in science or language, and some are cross curricular. SITES M2 painted a picture of classrooms where students are actively engaged in activities such as searching for information, designing products, and publishing and presenting the results of their work (Kozma, 2003). Students often collaborate with each other and occasionally with others outside the classroom, such as students from other countries. From a majority of the cases it is reported that teachers create structure for students by organising student activities, advise students and monitor or assess student performance. Furthermore teachers generally collaborate with other teachers as part of their innovation (ibid).

All of the three studies described above seem to conclude that the teacher plays a crucial role in ICT rich learning environments.

2.3 Research paradigms in ICT

It is necessary to know something about general perspectives on ICT in education to understand how it can be applied in classrooms. Koschmann (1996) argues that from a Kuhnian perspective, instructional technology has undergone several paradigmatic shifts, and that these shifts have been driven by shifts in underlying psychological theories of learning and instruction. He has identified the following four paradigms:

2.3.1 Computer-Assisted Instruction (CAI)

Koschmann (ibid) traces the emergence of CAI to IBM's release of the first CAI authoring tool in 1960. Applications developed under this paradigm tend to be straightforward and practical instructional tools designed around the identified needs of the classroom, hence reflecting the beliefs and attitudes of the general education community. Learning is seen as the passive acquisition or absorption of an established body of information, and instruction becomes a process of transmission or delivery. CAI applications utilize a strategy of identifying a specific set of learning goals, decomposing these goals into a set of simpler component tasks, and finally, developing a sequence of activities designed to result in the achievement of the original learning objectives (e.g. Light & Littleton, 1999). Research in this paradigm has been dominated by a behaviourist and experimentalist tradition. Throughout its history, this tradition has favoured technology-driven research in which the emergence of some form of technology stimulates a research to evaluate its effects on learning outcomes (Koschmann, 1996).

2.3.2 Intelligent Tutoring Systems (ITS)

ITS arose in the early 1970s, when workers from the field of Artificial Intelligence (AI) research immigrated into the educational arena. According to Koschmann (ibid), the paradigm is founded on the proposition that education could be globally improved by providing every student with a personal (machine-based) tutor. Learning is seen as the process by which a problem solver acquires a proper representation of a problem space, hence, instruction consists of activities designed to facilitate the acquisition of such a representation by the learner. The role of technology in this process resonates the one within the CAI paradigm. However, ITS aspires to having a greater degree of interaction, flexibility and ability to handle complex problems. The research approach in this paradigm is explicitly cognitive and the research focus is on the fidelity of the system's performance, rather than its effect on student learning outcomes. CAI and ITS have much in common in that both reflect notions of knowledge as given and of teachers as the final authority. Both embrace a view of teaching as delivery(ibid).

2.3.3 Logo-as-Latin

According to Koschmann (1996), Logo-as-Latin emerged from a constructivist perspective on learning, viewing knowledge as acquired through a process of subjective construction, in contrast to learning as transfer in CAI and ITS. One assumes that by engaging in activities of programming-designing, building, and debugging programs – the learner acquires cognitive benefits that extend beyond simply learning to code in a particular language. Research in this paradigm focuses specifically on the issue of instructional transfer.

2.3.4 Computer Supported Collaborative Learning (CSCL)

Koschmann (1996) suggests that a forth paradigm; CSCL is emerging, which focuses on the use of technology as a mediational tool within collaborative methods of instruction.

The scarcity of computers in schools almost demanded that students were organized to work at them in small groups. Hence, one of the spin-off effects of computers in early education has been the growth of interest among developmental psychologists in collaborative learning (Crook, 1999). Crook argues that computers made student interaction visible to researchers and suggests an attractively bounded situation for studying productive interaction (ibid). However, it is not only practical considerations which dictate this pattern of computer use. Many teachers believe that the computers provide students an excellent environment in which they can both learn to work together in groups, and work together in groups in order to learn (Littleton, 1999).

In contrast to the first three paradigms mentioned above, which all approach learning and instruction as psychological matters, and where traditional methods of psychological experimentations are used, CSCL is built on research traditions from other disciplines devoted to understanding language, culture and other aspects of the social setting. Koschmann (1996) argues that the perspectives of social constructivism, sociocultural theories and theories of situated cognition provide the intellectual heritage from which CSCL has emerged as a new paradigm for research in instructional technology. In this paradigm, learning is conceived as interconnected with language, culture and the social and material ordering of the settings in which people learn. The model of instruction underlying work in CSCL is termed collaborative learning (see Koschmann, 1996 for elaboration on collaborative learning), and an important focus of research has been on how technology may serve to support collaborative methods of instruction. Unlike the types of issues (i.e. instructional efficacy, instructional competence, instructional transfer) underlying the previous paradigms, research in CSCL is concerned with instruction as enacted practice. The field of CSCL is now established with its own conferences[18] and web-sites[19]. Social

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[18] E.g.: http://www.euro-cscl.org/Research/#CSCL_conferences

[19] E.g.: http://www.euro-cscl.org/

constructivist and sociocultural perspectives form some of the basis from which CSCL has emerged, and some features of these perspectives will be described in the next section.

2.4 ICT and the social construction of knowledge

During the past decades, science teaching has been significantly influenced by a constructivist perspective on learning. Mortimer and Scott (2003) suggest that although the term constructivism is used very broadly, at least the following two main features seem to be shared by constructivists: a) that learning requires active intellectual involvement of students, and b) that the students' prior knowledge influences subsequent learning of scientific concepts. However, many scholars emphasise that we need to recognise that knowledge exists as a social entity and not just as an individual possession (e.g. Mercer, 1995). According to Greeno, Collins and Resnick (1996), research on cognition and learning has illustrated that students learn best by actively "constructing" knowledge from a combination of experience, interpretation and structured interaction with peers and teachers. The focus on interaction with peers and teachers includes a social dimension of learning, bringing forth another perspective on learning that increasingly is drawn upon in science education: the sociocultural approach, having its origin in Vygotskian and neo-Vygotskian psychology. According to a sociocultural view, learning and meaning making are portrayed as originating in social interactions between individuals, or as individuals interact with cultural products that are made available to them in the form of books or other sources. Communication between the actors and the use of different technologies constitutes the social practice or learning environments (Vygotsky, 1978; Säljö, 2001; Leach & Scott, 2003; Ludvigsen, 2005).

Cultural products or artefacts are central in a sociocultural perspective on learning. Ludvigsen (2005) argues that we cannot understand learning without simultaneously understanding how artefacts[20] are involved in the interaction. Moreover, in the sociocultural tradition, continuity between thought and language is of crucial importance. This inevitably highlights the role of language in the construction of knowledge. Individually and collectively we use language to transform experience into knowledge and understanding. Hence, the discourse and the mastery of communicative and intellectual tools are central in the learning process. According to Vygotsky, language and other semiotic mechanisms provide the means for scientific ideas to be talked through between people on the social plane. The link between an individual and a sociocultural view of learning lies in the concept of *internalisation*. Internalisation denotes the process where the learner reorganizes and reconstructs talk and activities from the social arena (Vygotsky 1978). Internalisation does not involve direct transfer of the discourse from the social to the internal plane. There has to be a step with personal interpretation where the individual comes to a personal understanding of ideas encountered at the social plane (Leach & Scott, 2003). In this respect, Vygotskian theory shares common ground with the basic tenets of constructivism mentioned above; in recognizing that the learner cannot be a passive recipient of knowledge and instruction. However, it must be recognised that the sociocultural perspective goes much beyond this, in developing a view of what is involved in teaching and learning (Mortimer & Scott, 2000). According to Leach and Scott (2003), it may be useful to employ aspects from a sociocultural, as well as an individual view of learning to understand teaching and learning in science. It is insufficient to focus on students "mental structures" to explain how students learn science in classrooms, hence consideration of the social environment through which learners encounters scientific ideas is also necessary.

Vygotsky (1978) introduced the term *zone of proximal development (ZPD)*, which may be understood as the distance between what an individual can manage on its own, and what the individual can manage with support from other and more competent persons. For students to

[20] Ludvigsen (2005) uses artefact as synonymous with cultural tool. An artefact can for instance be a book, a calculator or a computer where earlier experiences and knowledge are stored. When artefacts are used, we make use of accumulated and collective knowledge.

expand their ZPD, the teacher must arrange activities that facilitate student learning, for instance with the help of mediating tools. Such tools may include language, signs and models that visualise the thinking and scaffold[21] [22] students in their aspirations to expand their ZPD. Scientific knowledge is not there to be seen in the material world; rather, it exists in the language, practices and semiotic systems used within specific communities to account for aspects of the material world (Leach & Scott, 2002). Students will not stumble upon the formalisms, theories and practices that form the content of science curricula without guidance from other persons or tools. Hence, the role of the teacher is vital in introducing and supporting the use of new knowledge on the social plane of the classroom (Leach & Scott, 2002; Mortimer & Scott, 2003).

The widespread access to ICT in society brings along changed conditions for learning and communication. The sociocultural perspective on learning is often used as a means to understand and interpret how students learn when they use ICT as mediating tools. During the last decades, there has been an increasing focus on learning situations organised as a form of interaction among peers and among teachers and students. It has been suggested that ICT will facilitate collaboration within the classroom itself and provide new ways of working together (e.g. Säljö, 1999). Furthermore, ICT contains tools that can support the learning process in different ways as compared to traditional texts. For instance ICT renders the possibility for interactivity between computer and human, and visualisations can make the invisible visible. Crook (1999) suggests four ways that computers may influence interactions in the classroom: *1) Interactions **at** computers* may acquire a collaborative quality where two or more learners gather at a particular place to solve a problem together. This is the most familiar and studied sense of collaboration. For instance, in the Spoken Language and New Technology (SLANT) project, Mercer and colleagues observed children

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[21] The concept of scaffolding was first introduced by Bruner and colleagues (Wood, Bruner, & Ross, 1976).

[22] Mercer (1995) argues that scaffolding describes a quality of the process of teaching and learning which both "progressive" and "traditional" ideologies of education tend to ignore. It represents both teacher and learner as active participants in the construction of knowledge. The essence of the concept of scaffolding, as used by Bruner is the sensitive, supportive intervention of a teacher in the progress of a learner who is actively involved in some specific task, but not quite able to manage the task alone.

engaged in computer-based joint activities. One outcome was a typification of three different types of talk: *disputational, cumulative* and *exploratory* (Mercer, 1995; Mercer, Wegerif, & Dawes, 1999). The focus on how particular ways of talking around the computer support students' joint construction of knowledge and understanding have been further developed by Mercer and colleagues (e.g. Mercer, 2000; Dawes, 2004). A central result from this work is the documentation of the close connection between the teacher's instruction, the use of ICT and the quality of peer interaction. *2) Interactions may occur **around** computers*. In this case, a loosely knit group of people are sharing a number of workstations housed in a common space. This ecology allows a degree of more casual and improvised exchange. *3) Interactions **through** computers* are possible when the social organisation is asynchronous. Here the partners are separated in time and space but a networking of the technology creates a novel opportunity for users to construct some degree of common knowledge. *4) Interactions may occur **in relation to** some computer application*. The focus here is on circumstances where the crucial feature of the computer's mediation is not dependent on current interaction with the technology. The interaction described in paper III and IV of this thesis (Mork, 2005; Mork, in prep.-b), illustrate examples of this last type of interaction facilitated by computers.

It can also be argued that the possibilities for interactivity, communication and access to information that are possible with ICT represent a threat to the well established traditional interaction in the classroom. With the computer as a tool in the classroom, several basic rules for how to communicate seem to be changed (e.g. Littleton, K. & Light, 1999; Säljö, 2001). Analysis of classroom communication in ICT rich environments indicate that the discourse patterns change because the teacher acts more as a supervisor and assistant, as compared to a lecturer (e.g. Schofield, 1995). At the same time learning changes towards being characterised more as production than reproduction, which according to Säljö (2001) is one of the most revolutionising aspects of the influence of ICT.

2.5 Language and argumentation

In the present section I wish to focus on language and especially argumentation; a central theme in paper III and IV.

> *A significant insight that has developed over the last 50 years, and is yet only partially realised at the level of the classroom, concerns the important role language plays in learning and in the design of effective learning environments. A prominent, if not central, feature of the language of scientific enquiry is debate and argumentation around competing theories, methodologies and aims. Such language activities are central to doing and learning science (Duschl & Osborne, 2002, p 40).*

Talk is a prominent feature of human knowledge and learning: knowledge is not merely stored in our minds; it circulates between us when we communicate with each other in concrete activities (Säljö, 1999). In a sociocultural perspective on learning, language is perceived as a mediating artifact, and a tool for thought. Vygotsky described language as having two main functions: as a *communicative tool* for sharing and jointly developing the knowledge which enables organised human social life to exist and continue, and as a *psychological tool* for organising our individual thoughts, for reasoning, planning and reviewing our actions (Vygotsky, 1987). Developing a better understanding of how we can use language to combine our intellectua l resources has some useful, practical outcomes for education. Paper III in the present thesis aims at contributing to such understanding by introducing a novel approach to analysing student argumentation in terms of both structure and content.

A major trend in science education research internationally is the focus on the significance of language and argumentation when learning science (Lemke, 1990; Kuhn, 1993; Wellington & Osborne, 2001; Duschl & Osborne, 2002; Mortimer & Scott, 2003). Even though science is about material things and physical relationships, and is represented in technologies and artefacts, it is shared through words and formulae (Mercer, 2000). Argumentation is particularly relevant in science education since there is now a well-attested body of empirical evidence that science emerges as uncertain, contentious and often unable to provide answers to the many important questions with any required degree of confidence (Jenkins, 2002). Driver et al. (2000) emphasise the importance of educating students in skills of argumentation since there are many areas of public science-based policy in which the public has a legitimate voice. Many of these issues are complex, and the science underlying them may be uncertain.

According to Millar and Osborne (1998), there is a growing body of evidence that engaging in argumentation generates the kind of knowledge and understanding essential to scientific literacy; and there is some evidence that argumentation improves student engagement and interest in science. Säljö (1999) claims that creation of knowledge essentially is a matter of learning to argue. Consequently students must be engaged in activities that require them to use the language and reasoning of science with their peers and teachers. Even though an increasing number of studies within the field of science education report on such activities, they seem to report on exceptions rather than common practices in science classrooms. Paper IV in this thesis discusses possible reasons why activities promoting argumentation are not more common. Furthermore, a framework of potential difficulties that may be encountered in such activities and possible teacher interventions is put forth.

To engage in discussion and argumentation, one needs some kind of issue or theme to talk about. ICT tools have great potential to both provide argument constructing tools and multiple sources of discipline-specific knowledge as a basis for students' conversations and debates. Argument construction tools help students interpret their existing and new ideas, and propels learners to compare and organize their ideas to build more coherent and cohesive explanations (Duschl & Osborne, 2002). Several different computer-based learning environments have been specifically designed to support students in their construction of arguments and explanations, for instance *CSILE*[23] (Scardamalia & Bereiter, 1991) and *SenseMaker* (Bell, 2004).

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[23] CSILE became Knowledge Forum in 1997. Today Knowledge Forum version 5 is under development, and Knowledge Forum is used at all levels of education, health care, community and business contexts, in America, Asia, Australia, Europe and New Zealand (Scardamalia, 2004).

The Computer Supported Intentional Learning Environments (CSILE)/Knowledge Forum is an interesting ICT project in science education, that aims to facilitate the establishment of a learning environment similar to scientific communities (Scardamalia & Bereiter, 1996). The heart of CSILE/Knowledge Forum is a multimedia community knowledge space. In the form of notes, participants contribute theories, working models, plans, evidence, reference material, and so forth to this shared space (Scardamalia, 2004). The software provides knowledge building supports both in the creation of notes and in the ways they are displayed, linked, and made objects of further work (ibid).

SenseMaker is an argument constructing tool developed by the WISE project, that allows students to use Internet materials to represent arguments about complex scientific topics such as "How far does light go?" (Bell, 2004). Research programs on design of argument construction tools raise questions about ideas, the scope of argument, and the criteria that students may use to link ideas (Linn, 2003). For example, Bell and Linn (2000) found that students gained more integrated and normative ideas about light when they prepared to argue both sides of the question than when they only prepared an argument for one view. Paper III and IV in this thesis, include examples on the use of argumentation in a role-play debate preceded by the Viten program *Wolves in Norway* (Mork, 2005; Mork, in prep.-b). This activity helps the teacher understand how students make sense of the information from the learning materials, and lets students use their newly gained knowledge while practicing argumentation skills.

2.6 ICT in science education

ICT has the potential to play an important role in making school science more relevant, interesting and motivating for students, and it offers opportunities to dissolve the boundaries between school and society. According to Linn (2003) students today need to learn how to search databases, interpret models, and critique electronic resources to succeed in school and in the workplace. Digital technologies offer new resources for learning, support new modes of instruction, and amplify opportunities for science education research (ibid). Osborne and Hennessey (2003), in their comprehensive overview: *Literature Review in Science Education and the Role of ICT: Promise, Problems and Future Directions,* propose a range of various ICT-tools for use in school science activities: multimedia software for simulation of processes and carrying out 'virtual experiments', publishing and presentation tools, digital recording equipment, computer projection technology, computer-controlled microscope and tools for data capture, data logging systems, databases and spreadsheets, graphing tools and modelling environments. They further argue that these forms of ICT can enhance both the practical and theoretical aspects of science teaching and learning, and suggest that the potential contribution of technology use can be conceptualised in six ways:

1. Expediting and enhancing work production

Expediting and enhancing work production may offer release from laborious manual processes and more time for thinking, discussion and interpretation. McFarlane and Sakellariou (2002) suggest that computer-based simulations may provide better support for the development of theoretical understanding than practical work, for three main reasons: Firstly, the competence in handling an apparatus is no longer an issue, secondly the simulation can offer simultaneous representations of the real and the theoretical behaviour of the system under investigation for comparison (e.g. a particle model alongside a melting ice cube), and finally, the data sets generated can be more extensive than could be gathered experimentally by one group or class of students. As described in paper II in this thesis, in the Viten program *Radioactivity* virtual samples are easily collected and analysed through simulations at the virtual laboratory. No time is spent finding samples and setting up equipment, thus the focus is on the samples; what the different types of instruments actually can measure, and interpreting and discussing the results (Mork, in prep.-a).

2. Increasing currency and scope of relevant phenomena

Increasing currency and scope of relevant phenomena by linking school science to contemporary science and providing access to experiences not otherwise feasible enhances the teaching of science. The Viten program *Wolves in Norway* provides a contemporary socioscientific conflict in the Norwegian context. This topic is often debated in the media becoming relevant to students as it relates school science to the contemporary world. By using web-based learning materials, the authenticity is increased by continuously updating the content of the program (See paper I og II Mork & Jorde, 2004; Mork, in prep.a). There are several examples where students can communicate with researchers and participate in research projects in collaboration with others. The Norwegian initiative Network for learning about the environment[24] focuses on education for sustainable development. Their web-site is a meeting place established to promote collaboration between schools, environmental management authorities, research institutions and voluntary organisations, containing a range of projects to choose between. The web-site includes activities for students, ideas for teaching and a database for each topic. Schools can use information from other participants, but also register their own observations in the database. In this way data from local schools can be used by other schools and by researchers and management authorities. 2216 Norwegian schools are now participants in this network. Another example is the international GLOBE program[25], a worldwide hands-on primary and secondary school-based education and science program. GLOBE provides students the opportunities to take scientifically valid measurements in the fields of atmosphere, hydrology, soils, and land cover. Students can report their data through the Internet, create maps and graphs on the interactive Web site to analyze data sets and collaborate with scientists and other students around the world. Since 1995, 71 Norwegian schools[26] have joined the GLOBE program.

[24] http://miljolare.no

[25] http://www.globe.gov/globe_flash.html

[26] http://www.dalen.vgs.no/globe/Main.htm

3. Supporting exploration and experimentation by providing immediate, visual feedback.

The use of graphing or modelling tools provides dynamic, visual representations of data collected electronically or otherwise. Through providing immediate link between an activity and its results, the likelihood is increased that pupils will relate the graphical representation of relationships to the activity itself (Osborne & Hennessy, 2003). In the Viten program *Climate changes in the Arctic,* students learn about the greenhouse effect and how an increased mean temperature on earth is threatening the ecosystem in the Arctic. Through the use of animation and interactive tasks, students learn about climate models and how scientists use such models to predict future climate trends. Students also explore an interactive climate model provided in the program, and interpret graphics and reflect on the consequences from four different scenarios.

4. Focusing attention on over-arching issues

The interactive nature of tools such as simulations, data analysis software and graphing technologies can be influential in allowing students to visualise processes more clearly. Computer analytic facilities are advantageous over manual methods in allowing a more holistic and qualitative approach to pupil analysis of trends and relationships between variables in a graph rather than individual data points (ibid)

5. Fostering self-regulated and collaborative learning.

Students working with various tasks at the computer may work more independently of the teacher, and at their own pace. Digital learning environments can be designed so that students can work collaboratively (Scardamalia & Bereiter, 1996; Linn et al., 2003). Viten programs are also quite self instructive and may be worked on individually, however, students are encouraged to work in pairs. In *Wolves in Norway,* students work in pairs through the online part of the program. When preparing and conducting the role-play debate, students work in groups of 4-5 or whole class (See paper I og II Mork & Jorde, 2004; Mork, in prep.a).

6. Improving motivation and engagement.

The idea that using ICT enhances student motivation has gained currency in recent years (Campbell, 1984; Rieber, 1991; Schofield, 1995; Cox, 2000; Strømme, 2004). Schofield (1995) suggests a range of potential reasons for increased motivation including: novelty value, variety from teachers' lecturing, ICT-skills are useful later in life, using various ICT application can be challenging in contrast to ordinary school work, students are in control and can work at their own pace, and finally, some ICT tools may give rapid feedback. Many of these reasons overlap with students opinions of the Viten program *Radioactivity*, as reported in paper II in this thesis (Mork, in prep.a).

Research on implementation of ICT in schools now seems to have moved from a strong technology-based focus e.g. on registering number of computers and amount of time spent using ICT in schools (Quale, 2000; Kløvstad & Kristiansen, 2004; UFD, 2005), towards a focus on how technology best can be exploited to promote learning (Erstad, 2004). A review of studies conducted in a range of subjects in primary and secondary education showed a strong relationship between ways in which ICT was used and attainment outcomes (Cox & Webb 2004), suggesting that the crucial component in the use of ICT in learning and teaching is the teacher and her pedagogical approaches; a proposition resonating throughout the initiative in *Program for digital competence* (UFD, 2004a). Cox and Webb (2004) argue that the most effective uses of ICT are those in which the teacher and the software can challenge pupils' understanding and thinking, either through whole-class discussions, using an interactive whiteboard or through individual or paired work on a computer. Both whole-class and individual work can be equally effective if the teacher has the skills to organise and stimulate the ICT-based activity. I believe that teachers need a range of examples on how to effectively utilise ICT in their teaching. Paper IV illustrates an example of how a teacher uses a web-based Viten program as a stimulus for a role-play debate on a controversial issue.

As indicated above, current research suggests that it is not appropriate to assume that the introduction of new technologies necessarily will transform science education. Visiting a randomly chosen science classroom may confirm this. There is a need for developing and offering teachers a wide range of digital tools and learning materials so that each teacher can choose materials appropriate for their purpose. As argued elsewhere (Mork & Jorde, 2005), access to multiple digital tools and learning materials may increase teachers motivation and creativity regarding use of ICT in their science lessons. This argument is included in the propositions on how to reach the goal of developing digital skills in the new curriculum initiatives in Norway (ITU, 2005).

Developers of digital teaching materials are meeting this challenge by designing and refining learning environments that support teachers and students in learning, instruction and assessment (Jorde et al., 2003; Linn, 2003). Research on science teaching and learning informs both the tailoring and customizing of learning environments. The most powerful environments enable students to carry out complex projects with substantial support from teachers, and include automated feedback mechanisms as well as embedded assessments (Linn, Davis et al., 2004).

2.7 The Web-Based Inquiry Science Environment (WISE)

The Viten project has its roots in WISE, hence in this section I provide a description of WISE, and the pedagogical principles that lie behind the development of WISE digital learning materials.

WISE[27] is a free on-line science learning environment for students in grades 4-12, developed by the WISE-project at the University of California, Berkeley. The integration of

[27] wise.berkeley.edu/

computers and later web-based applications is the focus of the Berkeley research group, which grew out of the Computer as Learning Partner (CLP)[28] project and the Knowledge Integration Environment (KIE)[29] project (Linn & Hsi, 2000). The WISE learning environment builds on these earlier projects, incorporating the ideas of learning with computers together with the integration of the Internet into the software platform (Jorde et al., 2003). WISE employs a partnership model for design in which scientists, teachers, educational researchers, and technology specialists collaboratively design inquiry materials and assessments (Bell & Linn, 2004). A library of about 50 learning resources is currently available at the WISE web-site.

In WISE, students work on inquiry projects on topics such as genetically modified food, earthquake prediction, and the deformed frog mystery. Students learn about, and respond to contemporary scientific controversies through designing, debating, and critiquing solutions.

The WISE learning environment, curriculum, and assessments are all designed according to the Scaffolded Knowledge Integration (SKI) framework for instruction (Linn & Hsi, 2000; Linn, Davies, & Eylon, 2004; Slotta, 2004). The Scaffolded Knowledge Integration framework includes four meta-principles that guide the design of inquiry activities and technologies. This framework has been continuously refined through years of classroom trials, comparing different approaches to guidance, and different designs for curriculum (Linn & Hsi, 2000; Linn et al., 2004). SKI provides a resource for the design of activities and assessments as well as for review criteria to help authors continuously improve their materials. According to Slotta (2004), the resulting framework thus synthesises research findings and captures the intricacies of science education in the classroom. By encouraging learners to connect new ideas and perspectives to their ideas about scientific phenomenon they are investigating, the framework promotes cohesive understanding (ibid). The four

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[28] clp.berkeley.edu/

[29] kie.berkeley.edu/

SKI-principles are: make science accessible, make thinking visible, help students learn from each other and promote autonomy and lifelong learning.

Make science accessible

Making science accessible involves firstly, encouraging students to build on their scientific ideas as they develop more and more powerful and useful pragmatic scientific principles (Linn, Davies et al., 2004). Secondly, encouraging students to investigate personally relevant problems and revisit their science ideas regularly. Thirdly, science inquiry activities should be scaffolded so students participate in diverse inquiry tasks (ibid).

Make thinking visible

Students should be challenged to articulate what they know and mean about scientific topics so that they are able to reconstruct their thinking when new ideas are presented (Jorde et al., 2003). One pragmatic pedagogical principle for making thinking visible is modelling the scientific process of considering alternative explanations and explaining mistakes. According to Linn, Davis et al. (2004), using the work of expert scientists as role models can encourage students to distinguish among their notions, interpret feedback from others, reconsider information in light of experimental findings, and develop a commitment to scientific endeavour. However, Linn and colleagues further argue that making expert thinking visible is much more easily advocated than accomplished. Textbooks for instance generally give the right answer or the conclusion rather than clarify the interpretive process, including pitfalls, wrong paths, and misunderstandings that occur along the way.

Another important pedagogical principle is to scaffold students in order to help them to explain their ideas to teachers, peers, experts and themselves (ibid). This can be promoted by students writing about their ideas, or expressing ideas orally through working in pairs, classroom debates etc. The last pragmatic pedagogical principle suggested by Linn et al., is providing multiple visual representations from varied media. Computer animations, modelling programs, dynamic representations, and scientific visualisations make scientific processes and ideas visible to students by illustrating how elements of the situation interact. Such multiple visual representations enable students to interact with complex, dynamic systems (Clark, 2004).

Help students learn from others

The third meta-principle takes advantage of the collective knowledge in a classroom community. Linn, Davis et al. (2004) suggest four pragmatic pedagogical principles for helping students learn from others. Firstly, students should be encouraged to listen to, and learn from each other. According to Hoadley (2004), learning can be improved when teachers design discussions to require responses to others. Secondly, technology-enhanced activities should be designed to promote productive and respectful interactions, like for instance discussion tools that enable students to take roles, participate anonymously, and think before acting. Thirdly, groups should be scaffolded to consider cultural values and to design criteria and standards. And finally, multiple social activity structures should be employed. Individuals can benefit from learning to communicate in discussions, debates, essays, and other formats (ibid).

Promote autonomy and lifelong learning

Promoting autonomy and lifelong learning involves establishing a rich, comprehensive inquiry process that students can apply to varied problems, both in science class and throughout their lives (Linn, Davis et al., 2004). The pragmatic pedagogical principles for promoting lifelong learning are to engage students in reflecting on their own scientific ideas and on monitoring their own progress in understanding science. Secondly, to engage students in varied, sustained science project experiences. Thirdly, to establish a general inquiry process suitable for diverse science projects that supports revisiting of ideas, since gaining a robust understanding requires revisiting of ideas in new contexts. And fourth, to engage students as critics of diverse scientific information and to establish generative forms.

2.8 Viten

I have used Viten as a tool to look at ICT in science teaching in the four papers in this dissertation. Viten is one example among many ICT-based learning materials. In this section I give a brief overview of the Viten design model, together with some of the features of Viten and principles behind the design of Viten programs.

The Norwegian Viten project has strong links to the WISE-project (Linn & Hsi, 2000; Jorde et al., 2003; Linn, 2003; Linn et al., 2003) and builds on ideas of exploring the effective uses of technology in supporting the way scientific information may be presented and used as students learn science. Viten provides three types of programs engaging students in: designing solutions to problems, debating controversial issues and investigating scientific phenomena. The development of Viten builds on many of the good solutions from WISE at the same time making improvements to the accessibility of the software. As in WISE, Viten programs are designed according to the SKI principles (See section 2.7). The main differences between WISE and Viten are found within the technical solutions and the visual design: Viten programs are made in Flash creating a different type of visual design, and of course Viten programs are written in Norwegian.

The research and design activities of Viten are based on a continuous improvement model (See Table 2.1) combining development of materials with classroom evaluation (Jorde et al., 2003). All Viten teaching programs are developed in teams consisting of teachers, science educators, ICT technicians and experts from the academic discipline. Once themes have been constructed using the Viten software toolbox, implementation studies are conducted in science classrooms where members of the Viten team participate as classroom researchers. In order to understand the challenges faced by teachers and their students while implementing Viten programs, one must take into account the realities of everyday life in science classrooms and school systems. Pre- and post testing is included as means of monitoring conceptual growth. Groups of students working in front of the screen or participating in debates are videotaped to better understand the role of social discourse in learning concepts. Responses collected in the Viten programs are used to analyse conceptual growth while students work with the programs. Students are interviewed before and after working with programs to provide information on their views on the use of ICT and their knowledge about actual science topics in contextual settings.

Table 2.1: *Overview of components in the Viten design model and its specifications.*

Viten design model	*Specifications*
1. Choice of topic	*Types of Viten programs:* *Designing solutions to problems* *Debating controversial issues* *Investigating scientific phenomena*
2. Establishment of expert group	*Group members:* *Programmer* *Science educator* *Subject expert* *Teacher/student*
3. Development of Viten program	*Design principles:* *Making science accessible* *Making thinking visible* *Help students learn from others* *Promote autonomy and lifelong learning*
4. Classroom trials/ Evaluation of results	*Data collection:* *Pretest/posttest/delayed posttest* *Classroom observations/video* *Student/teacher interviews* *Student logs*
5. Repeated revisions of program	*Main revision after classroom trials, but revision is a continuous process, as Viten constantly receive feedback from students, teachers and others. Programs are also revised when new information or research becomes available*

The Viten design model stresses the fact that students not only need scientific information when learning science, they also need to be able to apply that knowledge in actual situations. The model also emphasises the need to integrate scientific topics into other domains such as economics, history, geography and sociology, which may influence how society deals with scientific information in a broader context.

The Viten project draws on both individual and social perspectives on learning, as described above in section 2.4. As a research and development project, Viten also draws on experiences from corresponding research in other science education projects, and classroom research in general (e.g. Rieber, 1990; Mercer, 1995; Linn & Hsi, 2000; Mayer & Moreno, 2002; Mork, 2003; Linn, Davis et al., 2004; Mork & Jorde, 2004; Strømme, 2004). The primary aim of all Viten programs is that students should learn about the processes and products of science while using ICT in the social environment of the classroom. Learning science involves being introduced to the concepts, conventions, laws, theories, principles and the ways of working in science. It involves coming to appreciate how this knowledge can be applied to social, technological and environmental issues. The basic tools of science, such as laws and theories, are developed within the scientific community and have been, and continue to be, subject to processes of social validation (Mortimer and Scott 2003).

The SKI principles (section 2.7) are built into the design of all Viten programs. The SKI principle *Help students learn from others* is for instance used to encourage students to work in pairs in front of the computer while working on Viten programs. Some of the clearest benefits of classroom computer use arise from the fact that they lend themselves so well to collaborative modes of use (Crook, 1994). The Viten philosophy is that students must formulate and explain their own ideas to each other, and through discussion work out a common answer to tasks. Students like working in pairs, something that may also increase motivation. This work form can nourish confidence when students work on difficult topics, or if they are not comfortable with using computers.

Each student pair has their own electronic workbook, where the teacher can comment on their work at any time. All Viten programs are composed as learning environments providing a wide variety of activities like animations, note-taking tool, quizzes, video clips, interactive tasks, simulations, evidence pages, links to other web-pages, crosswords etc. Most Viten programs end with a final activity where students are challenged to apply information fom the program in contexts such as; an offline debate, write a newspaper article, an oral presentation or even the building of a greenhouse to grow plants in space. Figure 2.1 visualises the Viten student interface[30], including a pop-up window for reflection notes[31]. Students navigate through the program by following the steps in the menu on the left. Each heading in the menu is a unit consisting of several steps.

Figure 2.1: *Viten student interface showing pop-up notes window.*

Of the three Viten programs that were available when viten.no was launched in 2002, I choose to focus on *Wolves in Norway* and *Radioactivity*. I choose *Wolves in Norway* because of its nature, focusing on a controversial issue. Furthermore I had tried out *Wolves in Norway* in my own science classes as a teacher, yielding many interesting observations

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[30] This screen shot is taken from the Viten program *Dinosaurs and Fossils*, where the student mission is to collect evidence that support or reject the theory of kinship between dinosaurs and modern birds.

[31] The pop-up window in this case is the student researcher's field note book, where they register evidence from each location they visit on their virtual tour.

that I was eager to explore in other science classrooms. *Wolves in Norway* is described in more detail in paper I (Mork & Jorde, 2004). The *Radioactivity* program represented something new and exciting when it was launched in 2002. It was the first Viten program made in Flash, constructed as a case where students had a mission to solve. Moreover, *Radioactivity* deals with an invisible phenomenon and contains many animations and simulations. *Radioactivity* is described in detail in paper II (Mork, in prep.a).

2.9 My role in Viten

My first encounter with the Viten team was in 1999, when I was working as a lower secondary school science teacher. The Viten team conducted a pilot study on the first version of the *Cycles of Malaria* program in four of my science classes. In 2000 the Viten team returned to my science classes to test the *Wolves in Norway* program. The program was originally designed for secondary school, so before the classroom trials, I was involved in adapting the program for lower secondary school. Since 2001, I have been associated with the Viten team as a doctoral student; my scholarship funded by a grant from the Norwegian Network for IT-Research and Competence in Education (ITU). In 2003 the Norwegian Archive, Library and Museum Authority (ABM) funded the project "ABM – school and web" to connect schools to the activities of ABM – a project in which I have been engaged as a half time program developer.

Throughout my experience with the Viten project I have assumed four different roles; all of which have been valuable and challenging. I have been a teacher implementing the programs in my science classes, I have been involved in the development phase of Viten programs, I have been a researcher observing how Viten programs function in classrooms, and I been a program developer in the creation of new Viten programs.

My initial role in the Viten project was that of a critical teacher since I had knowledge of the target group and was myself educated as a Biologist. I was able to provide feedback on usability, both of the platform and the programs. Many of my comments on the usability of *Cycles of Malaria*, run from the WISE platform, were integrated into the creation of the Viten platform.

Fieldwork conducted as a part of my doctoral work took me away from the role of teacher and into that of researcher. My focus changed from concentrating mostly on my students, to gaining an overview of how Viten was being implemented in classroom settings. As a researcher, my attention became directed towards students, teachers, computers, and the interactions between them. Experiences from fieldwork were reported back to the Viten team so that they might be used in revisions of Viten programs.

In the Viten project, research and development go hand in hand. As a researcher informing development and revision of programs, I believe that my background as a teacher has been an advantage. I came into the project with knowledge about the national science curriculum for the target group, and an understanding about the concepts these students are able to understand. My teaching background also provided information on what students were "into", their general reading ability and time on task capabilities. The Viten team has always employed a model for development of Viten programs that is a continuous process such that information coming from classroom settings is invaluable for the improvement and development of Viten programs and the Viten platform.

In my latest role as curriculum developer in the Viten project I have had the opportunity to see the project from yet another side. The critical teacher role was able to provide comments for improvements to the Viten development team. As a curriculum developer, I now see just how difficult it is to combine the expertise of technology together with good pedagogical ideas in creating science programs. I certainly understand more clearly now why the program developers often sighed when I was in my critical teacher role having myself experienced just how difficult program development can be.

In the four years I have been a part of the Viten team I have been involved in activities often not entirely associated with my own doctoral work. I have made these decisions to work with Viten activities on my own and have not seen this in any way to be a conflict to my position as researcher and doctoral student. I have never felt that there were any conflicting interests between my research results and the Viten project. On the contrary, my experience is that the Viten team has been anxious to use the results from my studies as valuable information for program revisions in Viten – the *Wolves in Norway* program is a good example of this.

3 Introducing the papers

The purpose of this study has been twofold: exploring the use of Viten programs in real classroom settings and informing program development. The work introduced in this thesis is anchored both within the field of science education and the field of ICT.

When I came to this project, I was anxious to find out what students learnt, but also which parts of the Viten programs that seemed to promote learning, hence papers I and II. There are many studies reported in the science education literature which address design and evaluation of teaching sequences. In the majority of the cases, the effectiveness of the sequence is evaluated by comparing students' responses to specially designed test items, before and after teaching. According to Leach and Scott (2002) the use of such test items allows researchers to judge the effectiveness of the teaching in meeting specific learning goals. To answer some of my research questions I therefore used a pretest-posttest design focusing on the learning gains of individual students. Some would argue that this would be in conflict with a view of learning as a social process where language and other tools play important roles. However, I think Vygotsky's notion of *internalisation* opens for using the individual as the appropriate unit of analysis (Arnseth, 2004).

Even though coming to the conclusion above, in my development as a researcher, it became clear to me that to understand more about how and what students learn, I had to go in and study student discourse. Hence, the last two papers brought me to the field of argumentation. Finding the appropriate methodology for studying argumentation has been a challenge and in paper III, I ended up developing my own dual approach to analysing student argumentation in debates. Following naturally from paper III, the teacher role in classroom debates is investigated in paper IV.

3.1 Paper I

This paper concerns the type of Viten program that is centred around a controversial issue. The debated theme is the controversial question about the continued presence of grey wolves, *(Canis lupus),* in the Norwegian landscape. Large carnivores like the wolf are charismatic species with great public support, but as powerful predators also highly controversial, and they are often forced into small fragmented populations. The wolf was almost extinct in Norway 30 years ago and is now making a slow reappearance, with about 20-30 individuals at present. The wolf population is isolated and suffers from severe inbreeding depression (Liberg, Andre´n, Pedersen, Sand, Sejberg et al., 2005). The interest groups in this controversy are on one side dominated by sheep farmers, hunters, and people living in wolf-areas, while environmental protection organisations and often the general public dominate the other side. The Norwegian government is obliged to protect endangered species through the Bern convention, as well as several Norwegian laws. However, the government is under constant pressure from the farmers' interest organisations and local politicians in wolf-areas. In the winters of 2001 and 2005, the Directorate for Nature Management had planned actions to selectively eliminate parts of the wolf population in order to protect domestic livestock in certain regions of Norway. This decision also attracted international attention as was seen in the following headings in the New Scientist: "*Permission given to hunt endangered wolves"*[32], and *"Norway to kill 25% of its wolves"* in BBC News online[33]. Norwegian media also influence the wolf debate by reporting on the loss of livestock to predators by showing pictures of sheep torn apart and eaten by wolves. The fact that a bomb threat was called in before a TV debate about wolves in April 2004 illustrates how aggravated this conflict can be.

Environmental protection groups are asking whether one should make objective, biological, professional demands to ecological management of large carnivores in Norway, or whether such predators should be managed according to a political opinion These questions illustrate very well how an issue that is not controversial in a biological sense, becomes controversial when one takes into account economic, political and personal values. The developers of the Viten program *Wolves in Norway* had the aim of presenting factual evidence about the controversy, centred in biology, together with the conflicting viewpoints of different interest groups. *Wolves in Norway* gives students the opportunity to see how science is a part of the public debate and decision making process. To investigate what students learnt from this program I tried to answer the following research questions:

- *What learning gains were achieved related to the biology of wolves, ecological management and the controversial issue of wolves in Norway?*
- *To what extent did this learning influence the students' views on wolves?*
- *Were there any differences in the responses of girls and boys?*

Permission from the Data Inspectorate was obtained to register and use student written and oral utterances in science lessons for research purposes, as well as for making use of digital

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[32] http://www.newscientist.com/channel/life/mg18524832.900

[33] http://news.bbc.co.uk/1/hi/sci/tech/4194963.stm

pictures and video recordings. Students and parents were informed about the purpose and procedures of the study (see Appendix 1) and both students and parents gave their written approval since the students were younger than 16 years.

In this study I used a four-step design with individual pretest - teaching sequence - individual posttest and individual follow up after four months. This design is a routine practice in other Viten studies. Similar designs have for instance been widely adopted in research on peer facilitation of computer-based learning (Brown, 1992; Howe & Tolmie, 1999; Light & Littleton, 1999; Underwood & Underwood, 1999; Linn, Davis et al., 2004). No attempt was made to compare the teaching approach with more conventional approaches, since the aim of this study was to find out how the program functioned in an ordinary classroom setting with real students. Even though learning about ecological management and the relationship between predators and prey etc. is embedded in the national curriculum, approaching these issues through the wolf conflict is not common for Norwegian science teachers. There are also other well-known difficulties that are involved in making valid comparisons, for instance as argued by Brown (1992): real classroom situations are inherently multiple confounded, and it would take a lot of resources to unconfound them, even though this was hypothetically possible.

From a sociocultural perspective, language is perceived as a tool for thought (Vygotsky, 1987; Mercer, 1995), hence talking about an issue in front of the computer and in role-play debates may have influenced students learning process. Observations from the role-play debates convinced me that analysis of student discourse was a logical way to proceed with my investigation of Viten programs. This reflection was the background for papers III and IV in the thesis.

3.2 Paper II

Paper II is written in the same spirit as paper I and provides an example of a Viten program investigating a scientific phenomenon. The phenomenon in focus is radioactivity; a traditional topic in science education in secondary schools across the world. The Viten program *Radioactivity* has a novel approach to traditional content, placing students in a context where they have roles as journalists with a mission to solve.

This paper is based on an implementation study that was conducted during the spring of 2002, in four 10th grade classes that were using the Viten program *Radioactivity.* Out of the three Viten programs available when I did my fieldwork, *Radioactivity* is the one including most interactivity, animations and simulations and hence, the most representative for all the Viten programs available today. As illustrated in Table 1.1, at present *Radioactivity* is the Viten program with most users making it particularly interesting to explore. Research questions in paper II included:

- *What features of Radioactivity are likely to have an impact on student learning?*
- *What are students actually learning when using the Viten Radioactivity program?*
- *What are student's opinions about the Viten Radioactivity program?*

As in the first study, permission from the Data Inspectorate was obtained to conduct the study and register data. Students and parents were informed (See appendix 1) and gave their written approval. A four-step design with individual pretest - teaching sequence - individual posttest and individual follow up was used in this study. However, since the empirical study was conducted in April and the term ended in June[34], the follow up was given two months after the teaching, instead of four as in the first study.

[34] In Norway students switch school after 10th grade.

3.3 Paper III and paper IV

Papers III and IV are concerned with how the Viten learning materials are able to mediate science content and promote discourse. This is an important issue both from a science education, and an ICT point of view.

A generic conclusion from many ICT based studies is that the teacher plays a crucial role in ICT rich environments (Kozma, 2003; Wasson & Ludvigsen, 2003; Cox & Webb, 2004; Erstad, 2004). The teacher must have skills to organise and stimulate the ICT based activity if it is to be effective (Cox & Webb, 2004). However, the pedagogical use of ICT is not frequent in Norwegian classrooms, indicating that many teachers lack skills in such practices (Kløvstad & Kristiansen, 2004). Osborne and Hennessy (2003) suggest that pedagogy for using ICT effectively includes ensuring that use is appropriate and adds value to learning activities, structuring activities while offering pupils some responsibility, choice and opportunities for active participation, and creating time for discussion, reasoning, analysis and reflection. According to Ludvigsen (2005) such activities promote what can be understood as *higher order knowledge* and skills (For a review, see Wegerif, 2003). Higher order knowledge includes:

- *Ability to localising, collecting, choosing, classifying, sequencing, comparing, contrasting and analysing relevant information*
- *Being able to argue for actions and claims, draw consequences from facts, explain own thinking, make judgements based on evidence*
- *Asking relevant questions, define problems, plan and complete projects, predict results from experiments, test conclusions and ideas*
- *Developing ideas and hypothesis, create new solutions and use imagination*
- *Considering what one reads, listens to and does, develop new criteria for considering own and others work, see limitations in own knowledge and consider whether own insight is sufficient (Kolstø et al., submitted)*[35]

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[35] My translation.

Ludvigsen argues that all these functions involve a development from using information to integrating knowledge in problem solving (ibid). Handling multiple resources is central in developing higher order knowledge and skills, and several computer based learning environments are designed to promote the development of such activities (Scardamalia & Bereiter, 1996; Linn, Davis et al., 2004). Viten programs also are designed to support such activities however, as mentioned above the role of the teacher is crucial for organising and supporting students in their work.

Paper III

Paper III illustrates how Viten as a tool can be used as a basis for a debate. Debates and argumentation are regarded as important activities in science education and a range of studies have analysed student argumentation in science lessons. With a few exceptions (Zohar & Nemet, 2002; Sandoval & Millwood, 2005), the main focus in these studies has been on the structure and form of argument rather than the subject content. In this paper I focus on role-play debates following the work with *Wolves in Norway. Wolves in Norway* provides an authentic context for students to practicing argumentation skills. Hence, in such context students can use data as evidence to support not just singular claims, but networks of claims made to advance a position. My research questions are the following:

- *What is the content of students' argumentation?*
- *How does structure relate to content in students' argumentation?*

Paper IV

Paper IV follows naturally from paper III, and shows that the teacher is still the guide in the classroom. Paper IV provides an example on how one teacher uses digital learning materials as a basis for debate and argumentation. Despite the common conception that debate and argumentation are regarded as important in science education, activities involving such practices are not common in science education (Newton, Driver, & Osborne, 1999; Norrild, Angell, Bang, Larsen, Paulsen et al., 2001; Haug, 2003). Lack of skills amongst teachers in handling such activities has been suggested as one reason (e.g. J.T. Dillon, 1994; Driver et al., 2000). The focus of paper IV is the teacher role regarding management and teacher interventions in the role-play debates about wolves. A typology of teacher interventions and reasons for these is proposed, that may serve as a useful tool for student teachers and teachers not experienced in managing debates and discussions. The research questions are:

- *What are the reasons for teacher interventions in managing the debates?*
- *What types of interventions are used by the teacher to manage the debates?*

3.3.1 Video transcripts and translations

The video of the three debates referred to in papers III and IV is transcribed by myself. All utterances made by the teacher and students are transcribed. The students on the video come from a part of Norway[36] where a dialect that differs from written Norwegian[37] is used. In some cases the wording in the dialect differs from written Norwegian and the intonation decides the meaning of the utterance. I have lived in this area of Norway for 11 years and know this dialect, so when necessary, I have translated the wording to written Norwegian.

When the students on the video signal that they want to speak, I have put this in a parenthesis in the transcript: (asks for permission to speak) When breaks appear in the discourse I have marked this with … to indicate the break however, I have not registered how long the breaks are, as that is not the focus of my analysis.

In debate 1, utterance 33 and 35, a break is indicated with … However, in this case it is not a real break, but utterance 34 is put in while the student in utterance 33 and 35 is talking.

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[36] The city of Trondheim. The dialect is called *trøndersk*.

[37] Written Norwegian is called *bokmål*.

Some places I have indicated in a parenthesis when the teacher is addressing one group in particular, and this is obvious from gestures on the video, but not expressed orally.

Some places I have indicated a noun in a parenthesis when the students are using only a pronoun, e.g.: “they (wolves)…

All oral and written utterances were originally in Norwegian. These are translated into English word by word as carefully as possible, so that the English version remain as closely as possible to the original wordings in Norwegian. Professor Doris Jorde, with English as her mother tongue and Norwegian as a second language for more than 20 years, has been a consultant. All data analyses have been done on the English version, and are available in Appendix 2.

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Paper I

Mork, S. M., and Jorde, D. (2004). We know they love computers, but do they learn science? A study about the use of information technology and controversy in science instruction. Published in *Themes in Education*, 5(1), 69-100

In the journal print of this paper, some headings have disappeared and the texts in some table columns are merged. To avoid misunderstandings regarding content of the paper, I therefore choose to include my own version of the published paper, instead of the journal print. I confirm that no content in this paper is changed from the published version of the paper however; a translation of Norwegian titles into English in the reference list is added.

When we use the word dyads in paper I, we mean student pairs which is the term used in the later papers of this thesis.

In this paper, the concept of follow-up is used, whereas in later papers I use the notion delayed posttest.

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We Know they Love Computers, but do they Learn Science? Using Information Technology for Teaching about a Socio-scientific Controversy.

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ABSTRACT

In this paper we focus on students' learning gains with respect to their understanding of biology and ecological management from the use of a teaching program combining online and offline activities to teach about the socio-scientific controversial issue of wolves in Norway. Gender differences in response to the program and students' attitudes towards wolves are also investigated. The web-based part of the teaching program consists of an online knowledge base designed to promote discourse and argumentation while working at the computers and in an offline classroom debate. The participants were two Norwegian classes of students age 14-15, who followed the teaching program. A pretest-posttest design with a follow-up four months later was chosen to measure student learning gains. Our results show positive achievement from pretest to posttest and even after four months students continue to demonstrate high levels of retention. Girls have significantly higher scores on posttest and follow-up compared to boys. Our results also show that 2/3 of the students changed their attitudes towards wolves during work with this teaching program.

INTRODUCTION

Modern western societies are becoming more and more complex; due to exponential growth in many fields that has lead to both positive and negative impacts on the natural world and humans. Students will increasingly need skills for dealing with controversial issues as they prepare to participate in the democratic process. Science educators seem to agree that relevant, real-life contexts are important when teaching for scientific literacy. Knowledge about how students deal with scientific issues in real-life contexts is of relevance when designing curricula and teaching models aimed at science for citizenship (Jenkins, 1994; Driver, Leach, Millar, & Scott, 1996; Millar & Osborne, 1998; Aikenhead, 2000; Driver, Newton, & Osborne, 2000; Kolstø, 2001). According to Lemke (2001) it is a falsification of the nature of science to teach concepts outside of their social, economic, historical, and technological context. Concepts taught in this way are relatively useless in life, however well they may seem to be understood on a test. Students and teachers need to understand how science and science education are always a part of larger communities and their cultures, including the sense in which they take sides in social and cultural conflicts that extend far beyond the classroom (ibid).

The Norwegian people do not agree on the issues surrounding the presence of wolves in the landscape. The wolf was nearly extinct in Norway 30 years ago, and is now making a slow reappearance. The Norwegian government is obliged to protect endangered species such as wolves according to the Bern convention. Organisations engaged in protecting the environment and many in the general public support the government in this view. On the other side of this conflict are people living in wolf areas and powerful sheep farmers practicing free-range methods who see the re-introduction of wolves as a threat to their economic and personal wellbeing. The government has invested huge sums in research on efforts to protect sheep from predators, though losses are still reported. Through the use of dramatic pictures and reports of sheep killed by wolves, the media has had a tendency to present only one side of this controversy. A survey of attitudes towards wolves in four counties in south-eastern Norway shows that about 50% of the sample express varying degrees of fear of wolves (Bjerke & Kaltenborn, 2000). One of the intensions of the teaching program about wolves is to provide information that supports a more nuanced view on this matter.

Through the use of the Internet, it is easier to provide authentic data for students allowing them to make connections between basic knowledge and contexts in which that information might be used. Simulations and animations that make the unobservable observable are easily created. Scientific concepts are presented in new dimensions with the potential to make what often are difficult ideas in science more accessible to students. Information technology can make it easier to help students access, evaluate and make use of information that connects science to society and decision making processes. In this study we evaluate the use of a web-based teaching unit created for teaching about biology and a socio-scientific controversy in grades 8-10 in Norway. The teaching program is based on the controversial issue of whether or not we should have wolves in the Norwegian wilderness. By introducing students to a socio-scientific issue like the wolf controversy, we are placing science into an authentic context. The overall aims in this teaching unit are to let the students learn:

- *About the biology of wolves and their place in an ecosystem.*
- *About the concept of ecological management.*
- *About different viewpoints in a socio-scientific controversy in the Norwegian society.*
- *How to work together in groups to develop understanding of a socio-scientific issue.*
- *To participate in an actual debate about wolves in Norway, allowing the opportunity to construct and evaluate arguments on either side of the issue.*

The wolf program is developed within the Viten[1] platform; a pedagogical toolbox designed to integrate the use of information technology in the science curriculum. The Viten project is a Norwegian version of the WISE project[2] developed at the University of California, Berkeley. In this paper we will focus on evaluating the success of the Viten wolf program in meeting the first three of the overall aims: teaching students about the biology of wolves and the concept of ecological management and to introduce students to a controversial issue in the Norwegian society. We intend to answer the following research questions:

1. *What learning gains were achieved related to the biology of wolves, ecological management and the controversial issue of wolves in Norway?*
2. *To what extent did this learning influence the students view on wolves?*
3. *Were there any differences in the responses of girls and boys?*

THEORETICAL BACKGROUND

In recent years there has been a shift of focus away from viewing learning in terms only of cognitive processes in the individual, towards a view of learning as involving social contexts. A socio-cultural view of learning with a basis in the Vygotskian (1978) ideas about human development has emerged (Solomon, 1994; Scott, 1998; Säljö, 1999). Language is seen as central to the development of knowledge, and the mastering of communicative and intellectual tools is central to the learning process. The process of internalisation (Vygotsky, 1978), where the learner reorganizes and reconstructs talk and activities from the social arena, does not involve direct transfer of the discourse from the social to the internal plane. There has to be a step involving personal interpretation where the individual comes to a personal understanding of ideas encountered at the social plane (Leontiev, 1981; von Glaserfield, 1999; Leach & Scott, 2003). In this respect Vygotskian theory shares common ground with constructivist perspectives in recognizing that the learner cannot be a passive recipient of knowledge and instruction (Mortimer & Scott, 2000). The Viten wolf program provides the students with opportunities to discuss various tasks and activities on the social plane through work in dyads, small groups and in classroom debates. In this paper we investigate the effectiveness of these processes by evaluating the learning outcome of the individual students.

Learning has traditionally been associated with remembering information, but a more current question is: What is the best way of transforming information from a wide variety of sources into knowledge within the group or individual? There is a significant difference between information and knowledge as stated by Salomon (2000); information may be transferred, while knowledge

[1] The website http://**viten.no** is a Learning Management Content System (LMCS), launched in February 2002 and located in Norway.
[2] http://wise.berkeley.edu

must be constructed as a web of meaningful connections. All information found within Viten programs and links from the programs to other sources on the Internet, are selected by the program developers. However tasks and activities within the program are constructed in such a way that students have to make their own selection from the information provided when they construct their answers and transform information found within the program into knowledge.

Students cannot learn science on their own without guidance from other persons or tools. Vygotsky (1978) introduced the term zone of proximal development (ZPD), which may be understood as the distance between what an individual can manage on its own, without help from others, and what the individual can manage with support from other and more competent persons. Focus has centred mainly on the importance of the teacher's role in scaffolding students in the learning process. But this kind of support does not necessarily have to come from a person. Books and tools like information technology may also play important roles as scaffolds for students in the ZPD. The Viten teaching programs are designed both to serve as scaffolds giving students various kinds of feedback and challenges in their learning process (Mork, in prep), but also to provide opportunities for the teacher and other students to support individual students in their learning process.

Roschelle et al. (2000), in a review of studies investigating the effectiveness of computers as learning tools, say that technology may enhance how students learn by supporting the following four fundamental characteristics of learning: 1) active engagement, 2) participation in groups, 3) frequent interaction and feedback and finally, 4) connections to real-world contexts. Roschelle et al. further say that if we connect these ideas to learning in the science classroom, we are able to see how information technology may be used to enhance the teaching of science in a way that engages students to be active participants in the learning process. All of the four characteristics put forward by Roschelle et al. are found within the Viten program about wolves: Firstly it is connected to a real world context with the overall objective that students should learn about an existing controversial issue in the Norwegian society. Secondly active engagement is promoted by the way the wolf program is designed. Another overall aim is to let students work in pairs and encourage them to talk science when at the computer or in small groups when preparing and conducting an offline classroom debate. Frequent interaction and feedback are supported through the program itself, but also through teacher comments in student electronic workbooks and through work in dyads and groups.

According to Jorde (2002; 2003), knowing where to look for information and who to believe is perhaps more important than ever before, since there is no control over information flow. By connecting scientific literacy to computer literacy, we empower students with tools to engage in lifelong learning for responsible decision-making. ICT also provides new possibilities for teaching difficult concepts and ideas. Complex systems may now be simulated, experiments involving expensive equipment may be animated, controversial topics may easier be discussed with experts and people outside the immediate classroom, and information may be found linking school science to authentic science research. ICT may also make the process of connecting science to the real world easier. Our challenges are to help students' access to reliable resources, and help them with making sense of information and understanding the differences between science and anti-science (ibid).

THE VITEN WOLF UNIT

WISE/Viten is based on a theoretical framework for instruction called Scaffolded Knowledge Integration (SKI), (Linn & Hsi, 2000). This framework has been continuously refined through years of classroom trials, comparing different versions of technology tools, different approaches to guidance, and different designs for curriculum. SKI is the basis for all the WISE/Viten activities and includes four major principles that guide the design of successful inquiry activities and technologies.

The SKI-principles:
- *Making science accessible*
- *Make thinking visible*
- *Learn from each other*
- *Promote autonomous learning*

The development of the Viten programs is informed by a view of learning as a social process, where the use of language is crucial importance. Viten programs promote student learning at the individual level as well as in a group structure where 2-3 students work together at a computer, and tasks and activities in Viten programs are designed with aims to promote discussions and reflections amongst the students. This is also in line with Roger Säljö's (1999) claim that knowledge development is about learning to argue and that technology may be a resource that contributes to support discussions and argumentation. Results from video recordings of student interactions when working with the wolf program are not addressed in this paper, however many students comment in their logs that they view working in dyads as positive, an impression we also have from classroom observations.

"Wolves in Norway" is a theme well suited for teaching about socio-scientific controversy and science in a context, because it is an authentic ongoing debate in the Norwegian society. It is repeatedly put on stage by the media and it relates to students' everyday life. When teaching about controversy in science lessons, students are usually introduced to two different scientific views and work with evidence for and against these views. When connecting science to issues in society there are other conditions that must also be considered, such as laws, culture, opinions, and so on. In the wolf program the controversy sets a scientific view up against a social-, cultural- and business-related view. The wolf controversy illustrates some of the real challenges connected with science, but it also addresses the nature of science.

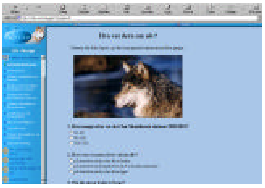
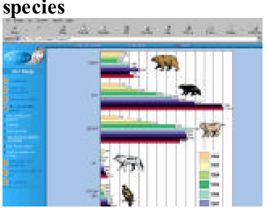
A vital aspect of this teaching program is the combination of online and offline activities. The online part, the knowledge base, is providing the students with information about the current issue; while the offline part, the debate, is the activity where the students are able to use this information in a real life context.

The focus in this study is evaluation of the wolf programs effectiveness in meeting the first three of the overall aims: Learning about the biology of wolves and their place in an ecosystem, learning about the concept of ecological management, and finally, learning about different viewpoints in a socio-scientific controversy in the Norwegian society.

The wolf program contains six main units and a cbsing activity as described in Table 1. One ambition with the program is to make connections between the biological and political content of this important debate in the Norwegian society. Concretely this is done by building each of the six main units on the previous one. In this way we hope students will be able to see the importance of basic biological knowledge in order to evaluate and argue in socio-scientific controversies. (Erlien, 2001).

Table 1: The wolf-program contains 6 main units and an offline debate as a closing activity.

Units in the program	Aims	Organization
1. Introduction 	▪ Introduce the students to the controversial issue of wolves in Norway. ▪ Map students' preconceptions about the danger of wolves. ▪ Map the students' attitudes towards wolves.	▪ Students work in dyads. ▪ Reading. ▪ Multiple-choice questions. ▪ Written tasks. ▪ View pictures.
2. Wolves and humans	▪ Introduce students to myths and fairytales about wolves to give a historical perspective on attitudes towards wolves. ▪ Introduce students to a research report about the danger of wolves.	▪ Students work in dyads. ▪ Reading. ▪ Written tasks. ▪ View pictures.

3. Facts about wolves 	▪ Learn about the biology of wolves. ▪ Practice interpreting and collecting information from graphical sources.	▪ Students work in dyads. ▪ Quiz. ▪ Reading. ▪ View animations and pictures. ▪ Plotting on a map. ▪ Written tasks. ▪ Interpret graphical sources. ▪ Follow links to web pages outside the Viten wolf program. ▪ Drop and drag activity.
4. Wolves and other species 	▪ Learn about how wolves influence other species. ▪ Learn about the connections in the ecosystem and be prepared to have science-based opinions about ecological management of wolves. ▪ Introduce students to the actual conflict of having wolves in the landscape. ▪ Practice in interpreting and collecting information from graphical sources.	▪ Students work in dyads. ▪ Watch video clip. ▪ Read. ▪ Written tasks. ▪ Follow links to web pages outside the Viten wolf program. ▪ Interpret graphical sources. ▪ View pictures.
5. Solutions to the conflict	▪ Introduce students to multiple ideas for the integration of wolves in the landscape. ▪ Practice interpreting and collecting information from graphical sources.	▪ Students work in dyads. ▪ Interpret graphical sources. ▪ Read. ▪ Written tasks. ▪ View pictures.
6. Attitudes towards wolves	▪ Introduce students to different attitudes towards wolves. ▪ Give students guidelines for how to evaluate arguments in interviews.	▪ Students work in dyads. ▪ Read. ▪ Evaluate argumentation in newspaper articles. ▪ Written tasks.
Closing Activity The closing activity is an offline debate conducted as a role-play where students are assigned different roles in a debate: for or against wolves in Norway. As they have worked through the wolf curriculum, they have had a type of mission to locate information that may be useful in the debate.	▪ Use information from the wolf program in constructing arguments in an offline debate. ▪ Practice evaluating other people's arguments, refute other people's arguments. ▪ Practice how to behave in a debate situation.	▪ Students work in groups of 3-5 students to prepare for the debate. ▪ Debate conducted as a role-play with two opposing groups.

To let the students learn about different viewpoints and attitudes towards wolves is an important overall aim of the wolf program. Since unit 6 deals with this matter we present this unit more in detail. This unit is introduced with a page containing clips of citations from the readers' column in a local Norwegian newspaper. The aim of this page is to introduce the students to different attitudes towards wolves. The next page prepares the students for a task where they are asked to evaluate the use of argumentation regarding wolves in two newspaper articles interviewing people about their views on wolves. The students are asked to view the text critically and evaluate the articles regarding credibility. They are asked to consider who the interviewed persons are, what interests they might have in this matter and which claims and reasons they give. The main objective of this page is to give students guidelines for evaluating arguments in interviews. In addition showing students examples of how other people are using argumentation about wolves is also a preparation for participation in the offline debate about wolves. The next page is a newspaper article where the interview object is arguing against wolves, while the following page is an article presenting the opposite view. Unit 6 closes with a task where students are first asked to present the arguments used by the two interview objects, and then asked with whom they agree most. In unit 6 we try to exploit the technology as a resource for supporting argumentation as suggested by Säljö (1999). The students are guided in, and provided with the opportunity to practice skills in how to evaluate arguments other than their own, skills that are important for lifelong learning (SKI-principle no 4).

METHODS

The data in this study were collected during the winter of 2002. The study includes two 9th grade classes from a culturally mixed school in a city in Norway, both of which implemented the wolf unit. The 59 9th grade students, age 14-15, had previous experience from using WISE, the American version of Viten. A design with individual pretest and posttest (Lund, 1997) and a follow-up four months later was chosen so that student achievement before and after use of the teaching program could be compared. For different reasons, not all students participated in all the tests: pretest (n=42), posttest (n=49) and follow-up (n=41). Thus the final sample of students attending all three tests was 38. The computer-based component of the curriculum lasted four hours during which students worked together in dyads at the computer. For different reasons four students were working alone. All the dyads consisted of either two boys or two girls. Two dyads in each class were video-recorded during the work with the computer-based part of the wolf curriculum. These students were also interviewed individually before and after the teaching sequence. Student pairs' electronic workbooks are also a part of the data material. Students were given one hour to prepare an offline debate, where they were assigned roles either for or against wolves in Norway. During the preparation for this debate students worked in groups of four-six. Finally, one hour was spent on the actual classroom debate. The complete data material also includes video recordings of the offline debate, interviews with the teachers and students logs; however, to address the research questions in this paper; only the results from the achievement tests are addressed.

Achievement tests

The paper and pencil pretest and posttest design was implemented with a follow-up test four months after the completion of the wolf curriculum. The follow-up is included in the research design to provide a realistic picture of retention. All tests have both multiple-choice questions and open-ended questions (see appendix), based on the learning goals of the teaching program. 10 multiple-choice questions (see appendix) and 7 open-ended questions are the same in all three tests, so that we could compare the students' preconceptions with information they had found in the teaching program. In addition all the tests contain some questions that are unique for the particular test.

The multiple-choice questions were given code 1 for right answers and code 0 for wrong answers. A coding scheme (see Table 2) was developed for open-ended questions, categorising right answers from code 1-3, where code 3 represented the highest score and wrong answers were given code 0.

According to research question 1, and the goals for the wolf program that are focused upon in this study, the achievement was assessed with respect to students' knowledge about the biology of wolves, ecological management and the wolf controversy in the Norwegian society. All the multiple-choice questions and question 4 and 6 in Table 2 are connected to the biology of wolves. Information about the preferred habitat types (question 4) is important for understanding the biology of wolves, e.g. the predator-prey relations, which is central for understanding the conflict in Norway, and for suggesting strategies for ecological management. The question about why wolves live in packs (question 6) is meant to reflect students' knowledge about the wolves' social behaviour and strategies for hunting and defending territories. To map students' knowledge about ecological management we asked if they knew where wolves are found in Norway today. This geographical information is important to understand why the issue of wolves in Norway is so controversial, providing information about actors in the conflict and is central for suggesting strategies of ecological management (question 7). Here we want to find out whether students are aware of the multiple ideas for integration of wolves into the landscape. Questions 2 and 3 provide information about the students' perception of the stakeholders' views in this conflict, and question 1 helps us assess if more information about whether wolves are dangerous or not made students change their views. The students' responses to question 1 will help us answer research question 2.

***Table 2**: Coding scheme for open-ended questions identical in all tests*[3].

	Questions	Code 1	Code 2	Code 3
1	*Are wolves dangerous or not? What is your opinion?*	*Dangerous/ not dangerous no justification.*	*Dangerous/ not dangerous incomplete justification.*	*Dangerous/ not dangerous. Scientific arguments like: dangerous only when provoked and under certain conditions. Small chance for attacks on humans. Have not killed humans since 1881.*
2	*Which arguments are used by those who want us to have wolves in Norway?*	*1 argument.*	*2-3 arguments.*	*4 or more arguments.*
3	*Which arguments are used by those who do not want us to have wolves in Norway?*	*1 argument.*	*2-3 arguments.*	*4 or more arguments.*
4	*What type of habitat is most preferred by wolves?*	*Imprecise, e.g. wild nature.*	*The woods* **or** *the mountains (just one of them).*	*The woods and the mountains.*
5	*Where in Norway do we find wolves today?*	*One of the following: Østerdalen, Østfold, the areas by the Swedish border.*	*Two of the following: Østerdalen, Østfold, the areas by the Swedish border.*	*All the following: Østerdalen, Østfold and the areas by the Swedish border.*
6	*Why do wolves usually live in packs?*	*1 argument.*	*2 arguments.*	*3 or more arguments.*
7	*Do you have any suggestions for how wolves and people can live together in the same area?*	*1 suggestion.*	*2 suggestions.*	*3 or more suggestions.*

Statistical tests

Statistical tests on gender differences were performed in SPSS 11.0.

RESULTS

Learning gains achieved

To evaluate the effectiveness of the Viten wolf program in reaching its aims, we measured the students learning gains according to the following aims: learning about the biology of wolves, learning about ecological management and learning about the controversial issue of wolves in Norway.

Figure 1 shows an overview of the results from individual students' mean score on pretest, posttest and follow-up. The scores related to each of the categories: biology of wolves, ecological management and the wolf controversy are based on two open-ended questions. Scores related to the

[3] Wrong answers were given 0 points.

biology of wolves are higher than scores in the other categories since they are also based on answers to 10 multiple-choice questions.

Figure 1: *Results from written test scores. N=38. Maximum test score = 31. Data from all the three content parts of the tests are based on two open-ended questions. In addition the part on the biology of wolves also contain answers to 10 multiple-choice questions*

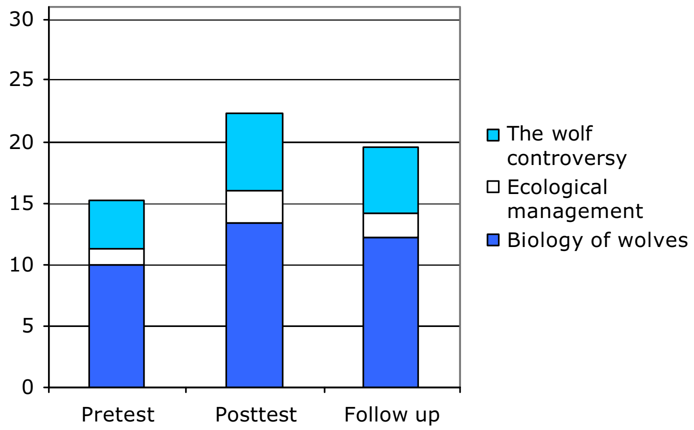


Figure 1 show that student scores were higher on the posttest compared to the pretest, and that even after four months students continued to demonstrate high levels of retention. In order to understand more about students' responses to the tests and the data behind figure 1, we will present some examples of individual student answers to open-ended questions. First we give some brief examples of answers to questions about the biology of wolves and ecological management. Afterwards we focus more in depth on student answers to questions about the wolf controversy and the view of different stakeholders since an important overall aim of the wolf program is to prepare for an offline debate on the controversial issue of wolves in Norway.

Example related to the biology of wolves

Learning about the biology of wolves is important for understanding why wolves in the Norwegian wilderness are controversial. In one example, the program provides information on how wolves hunt in packs through a simple animation with additional text. Here is an example of how Cecilie answers the question of why wolves usually live in packs.

Example 1: Cecilie
Question
English: Why do wolves usually live in packs?
Norwegian: Hvorfor lever ulv vanligvis i flokk?

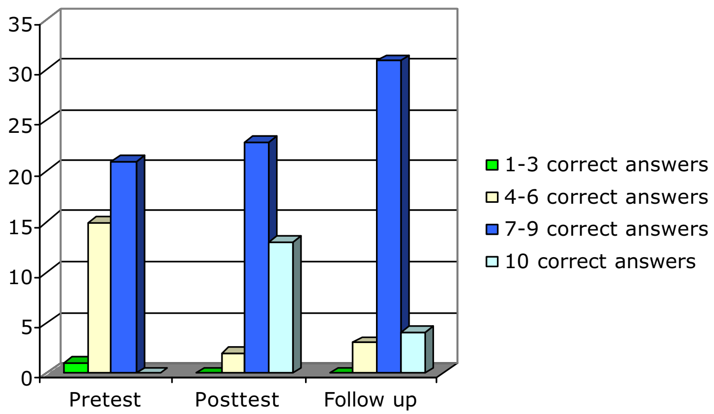
Pre-test:	***Post-test:***	***Follow-up:***
English		
It is easier to get hold	*Wolves mainly live in packs because it makes it easier to*	*Easier to defend the*

of an animal when there are several wolves I think.	*attack bigger animals like e.g. deer. Then one can distract the deer, while the others can attack it from behind. If several animals of the same species come into their territory it is easier to chase the intruders away.*	*territory. Easier to hunt.*
Norwegian:		
Det er lettere å få tak i et dyr når man er flere enn en tror jeg.	*Ulver lever hovedsakelig i flokk for at da er det lettere å angripe større dyr som f.eks hjort. Da kan en distrahere hjorten, mens de andre kan angripe bakfra. Hvis det kommer dyr av samme art i territoriet er det lettere å få jaget inntrengerne ut.*	*Lettere å forsvare territoriet. Lettere å jakte.*

In the pretest Cecilie (example 1) is insecure in her answer about wolves living in packs. Her argument is correct but quite limited. In the posttest she gives a much more elaborated answer demonstrating that she is familiar with wolves hunting tactics and she gives an example of which type of prey this tactic can be suitable for catching. She also mentions the advantage of living in a pack when defending the territory against other wolves. Cecilie uses the same arguments in the follow-up also. However, the quality of the answer is reduced since she is no longer using examples as backing of her argumentation. Cecilie's answers demonstrate a pattern that is representative for many students in this study, showing that in the pretest students give a kind of "common sense" argumentation, i.e. a very general answer that one might expect from persons with no particular interest or knowledge about this issue, while the answer in the posttest is more elaborate and much more specific. In the follow-up the answer is reduced to two very short arguments. This pattern is also reflected in figure 1.

All the multiple-choice questions common on the three tests were related to the biology of wolves. Figure 2 shows that at the pretest about half of the students have 7-9 correct answers. At the posttest and follow-up, the majority of the students had from 7-10 correct answers.

Figure 2: *Student score on multiple-choice questions on the three tests. N = 38. Maximum score is 10.*



Examples related to ecological management

The Norwegian government has suggested several strategies for ecological management as attempts to solve the wolf conflict. These strategies are presented in the Viten wolf program since knowing where we find wolves in Norway today is central to understanding the conflict. The Viten program asks students to mark on a map of Norway where they think wolves are found and then provides the correct information on the map in the next step of the program.

In example 2 we see that Svein's answer to this question on the pretest is the name of one of the wolf areas of Norway, Østerdalen. It is not surprising that Svein knows about this area since it is one of those that has been most focused in the media, especially after the government allowed 10 wolves to be killed there during the winter of 2001. In the posttest and follow-up Svein does not mention Østerdalen, but describes 2-3 other important wolf areas in Norway. Here it is interesting to note that Svein does not use the geographical names of these areas, he is just describing where they are on the map, a pattern found in the answers of several students to this particular question. Some students were also drawing maps and marking the wolf areas on the map.

Example 2: Svein

Question

English: Where in Norway do we find wolves today?

Norwegian: Hvor i Norge finnes det ulv i dag?

Pre-test:	***Post-test:***	***Follo- up:***
English		
In the Osterdalen.	*Today there are wolves along the Swedish border in the East and South, just below the Oslo fjord areas and higher towards East.*	*By the Swedish border in East and a bit higher up and a bit further down.*
Norwegian:		
Østerdalen.	*I dag finnes det ulv langs svenskegrensen i Øst/syd, like under Oslofjordområdene og høyere opp mot øst.*	*Ved svenskegrensen i Øst, og litt lengre høyere opp, og litt lengre ned.*

To the question about suggesting strategies for ecological management, Heidi has no answer in the pretest (example 3). However, in the posttest she gives an elaborated answer showing that she is familiar with strategies like fencing in livestock, using shepherds and limiting the living areas for wolves. What is most interesting in Heidi's posttest answer is that she reflects upon which of the strategies that is most preferable. In her follow-up Heidi provides three suggestions for what farmers can do. Two of these suggestions are actually different from those she used in the posttest. In the follow-up she suggests the use of shepherd dogs and limiting the grazing areas of sheep, but she does not suggest using shepherds and restricting the living areas of wolves as she did in the posttest.

Example 3: Heidi
Question
English: Do you have any suggestions to how wolves and humans can live together in the same area?
Norwegian: Har du noen forslag til hvordan ulv og mennesker kan leve sammen i det samme omraadet?

Pre-test:	***Post-test:***	***Follw-up:***
English		
No answer.	*In the same place? Then I suppose one have to set up fences to protect their livestock. There has actually been suggested limiting the living areas of wolves. I think that would function better. I don't understand why wolves and people have to live "on top of" each other. I don't see wolves as any threat to humans, so it must be if one has sheep and other animals. But one can use fences and shepherds and that kind of things.*	*There are more things the sheep farmers can do that they haven't tried yet. E.g. shepherd dogs, limit the grazing areas, electric fence and so on. Maybe this might work.*
Norwegian:		
Ikke besvart.	*På samme sted? Da må man vel sette opp gjerder for å beskytte husdyrene sine. Det har jo blitt lagt fram forslag om å begrense ulvens leveområde. Jeg tror nok heller at det vil fungere. Jeg skjønner ikke hvorfor ulv og mennesker må leve omtrent "oppå" hverandre. Jeg ser ikke på ulven som noen trussel mot mennesker, så det må vel være hvis man har sauer og andre dyr. Men man kan benytte gjerder og gjeterhunder og slike ting.*	*Det finnes flere ting sauebøndene kan gjøre som de ennå ikke har prøvd. Eks er gjeterhund, begrenset beiteområde, elektrisk gjerde osv. Kanskje dette kan fungere.*

Examples related to the wolf controversy

The recent increase in the wolf population in Norway has led to a relatively intense debate about the management of the species. One of the overall aims of the wolf program is to prepare the students to participate in an offline debate about the wolf controversy in Norway. Research on offline debates about the wolf controversy is reported in Mork and Jorde (2003). However, in this paper we focus on the aim that students should learn about different viewpoints in a socio-scientific controversy in the Norwegian society. It is therefore of particular interest to investigate student answers to questions about the views of the stakeholders in this conflict. Here we present examples of two students' arguments for wolves, and two students' arguments against wolves.

Example 4: Trude
Question
English: *Why do some people want to have wolves in Norway? (pretest) Which arguments are used by people who want wolves in Norway? (posttests)*
Norwegian: Hvorfor ønsker noen at vi skal ha ulv i Norge? (pretest) Hvilke argumenter for ulv brukes av de som er tilhengere av ulv i Norge? (posttest)

Pre-test:	***Post-test:***	***Follow-up:***
English		
Wolves have been in Norway for a long time and it would be a pity if we drive them to extinction.	*Wolverines kill many more sheep than the wolves. Very few people have been killed in Scandinavia the last centuries. 100 000 sheep are killed every year of other reasons than predators.*	*Predators keep the deer and moose population down. Not as dangerous as we think. Other predators, even golden eagle kill more sheep than wolves do.*

Norwegian:		
Ulven har lenge vært i Norge og det ville være dumt om vi utryddet den.	*Jerven tar mange flere sauer enn ulver. Veldig få mennesker er blitt drept i Skandinavia de siste århundrene. 100 000 sauer blir hvert år drept av andre årsaker enn rovdyr*	*Rovdyr holder hjortedyrbestanden nede. Ikke så farlig som vi vil ha det til. Andre rovdyr, t.o.m kongeørn tar flere sauer enn ulven gjør.*

Example 4 shows that in the pretest Trude's arguments for wolves are types of "common sense" arguments, i.e. they are very general and a type of argumentation one could expect from someone not very involved in this matter. This type of argumentation is similar to that of other students in this study. In the posttest Trude is using statistical information based on a research report about the danger of wolves as found in the wolf program. Her argumentation in the posttest focuses on the idea that the damage caused by wolves is not as bad as one might think. Trude claims that other predators kill more sheep than wolves and that wolves are not dangerous to people. It is also interesting to note that Trude, in contrast to most other students, points to the important fact that every year about 100 000 of the 130 000 grazing sheep that die or disappear, die from other reasons than predators. In her follow-up Trude uses the more general argument that predators keep the deer and moose population down, and thereby shows that she is familiar with ecological principles like relations between predators and prey. When saying that wolves are not as dangerous as people think, she backs up her argument with facts about other predators doing more damage to sheep than wolves. The qualitative difference in Trude's answers on the different tests is that in contrast to the pretest she is more specific, and uses more scientific concepts and statistical information in her argumentation in the two last tests.

Example 5: Heidi
Question
English: *Why do some people want to have wolves in Norway? (pretest) Which arguments are used by people who want wolves in Norway? (posttests)*
Norwegian: Hvorfor ønsker noen at vi skal ha ulv i Norge? (pretest) Hvilke argumenter for ulv brukes av de som er tilhengere av ulv i Norge? (posttest)

Pre-test:	***Post-test:***	***Follow-up:***
English		
Wolves are facinating animals and wolves are a natural part of the ecosystem in the woods. For those who are not bothered by wolves there is no reason to drive them to extinction	*Wolves have not killed (humans in Norway) for over a hundred years. Wolves are natural parts of the ecosystem in the woods and mountains. Norway is part of an agreement (don't remember the name) that commits us to taking care of the animals. It is wrong to drive the wolves to extinction only because they have killed some sheep. It is not wolves that have killed most sheep in Norway.*	*The wolves have not killed (humans in Norway) for more than 200 years. Are natural parts of the ecosystem in the nature. We are members of the Bern convention. It is wrong to drive a species to extinction. Wolverines kill more sheep than wolves.*

Norwegian:

Ulv er jo et fascinerende dyr og ulven er en naturlig del av økosystemet i skogen. For dem som ikke plages av ulv er det vel ingen grunn til at den skal utryddes.	*Ulven har ikke drept (mennesker i Norge) på over hundre år. Ulven er en naturlig del av økosystemet i skog og fjell. Norge er med i en avtale (husker ikke navnet) som forplikter oss til å ta vare på dyrene. Det er galt å utrydde ulven i Norge bare fordi den har drept noen sauer. Det er ikke ulven som har drept flest sauer i Norge.*	*Har ikke drept (mennesker i Norge) på 200 år. Er en naturlig del av økosystemet i naturen. Vi er medlem av Bernkonvensjonen. Det er galt å utrydde en art. Jerven dreper mer sau enn ulven.*

Heidi's argumentation in the pretest is based on feelings and she focuses on the values of the wolves as a species and that they are a natural part of the ecosystem. In the posttest she repeats the argumentation of wolves as a part of nature, and like Trude, Heidi is also basing her argumentation on statistical data from the research report about the danger of wolves. What makes Heidi's posttest interesting is that she refers to the Bern convention. She can't remember the name of it, but it is obvious that she is familiar with the content because she says that it commits us to taking care of animals. However, in the follow-up four months later Heidi actually uses the name of the Bern convention and she is still demonstrating that she is familiar with the content when she says that it is wrong to drive a species to extinction. The qualitative difference in Heidi's answers in the tests is that even though the very general argumentation in the pretest is repeated in the two other tests, Heidi supplements it with arguments based on statistical information and an argument that refers to an international agreement.

Trude's and Heidi's answers in the tests are representative for answers given by the other students in this study. Their answers also reflect the main arguments used by stakeholders arguing for wolves:

- *Wolves are not as dangerous as people think because:*
    - *Wolves have not killed humans in Norway the last 200 years.*
    - *Wolves kill fewer sheep than other predators.*
- *About 75% of sheep that die while grazing, die for other reasons than predators.*
- *Wolves are natural parts of the ecosystem.*
- *Norway has signed the Bern convention committing us to preventing the extinction of species.*
- *Predators are important to control prey populations like moose and deer.*

Let us now look into two examples of the kind of arguments students think people use when arguing against wolves.

Example 6: Karl
Question
English: Why are some people against having wolves in Norway? (pretest) Which arguments do people use who are against wolves in Norway? (posttests)
Norwegian: Hvorfor er noen motstandere av at vi skal ha ulv i Norge? (pretest) Hvilke argumenter mot ulv brukes av de som er motstandere av ulv i Norge? (posttest)

Pre-test*:*	***Post-test:***	***Follow-up:***
English		
Because their sheep are killed, and wolves often seem scary.	*People are afraid of wolves. It costs a lot of money to keep them away. Wolves kill more sheep per wolf than other predators. Wolves are on the top of the food chain. Wolves are dangerous to humans. Wolves can be moved to Sweden.*	*Wolves kill sheep, they are a threat to humans and animals, and they are on the top of the food chain. Farmers and others loose millions on loss of their livestock, and by fencing in livestock.*
Norwegian:		
Fordi sauene/dyrene dems blir drept, og ulven kan opptre skremmende.	*Folk er redde for ulv. Det koster penger å holde den borte. Ulven dreper mer sau per ulv enn andre dyr. Den er på toppen av næringskjeden. Den er farlig for mennesker. Den kan flyttes til Sverige.*	*De dreper sau, er en trussel for mennesker og dyr, de er på toppen av næringskjeden. Bonden og andre taper millioner av kroner på inngjerding og tapte dyr.*

Karl's arguments in the pretest are based on feelings, a typical trait for many student answers in the pretest. In his posttest he claims that people are afraid of wolves, and that wolves are dangerous to humans, but these claims are not supported by statistical evidence. What is most interesting in Karl's posttest answer is that he is obviously aware of the fact that other predators kill more sheep than wolves. However, as Karl correctly points out: individual wolves kill more sheep on average than individuals of other predator species like wolverines and bears. To get to this information, Karl must have been using a combination of information sources in the wolf program. A graphical representation in the wolf program provides information about the number of sheep killed by the different predator species every year. To get information on the population size of other predators than wolves it is necessary to follow links to web pages outside the Viten wolf program. Another interesting feature of Karl's answer is the claim that wolves are on the top of the food chain. He doesn't support this claim with backings in the posttest, but several students used this information when arguing in the offline debate: since wolves are on the top of the food chain, it doesn't influence other species very much if they are driven to extinction. This argumentation suggests some misunderstanding about population dynamics: the students only refer up trophic levels (stating that no animals depend upon wolves for food), rather than considering the effect of wolves on population size at lower trophic levels. Karl also brings in the economic dimension of this controversy when arguing that it is expensive to protect people and livestock against the wolves. In the follow-up four months later Karl repeats most of the arguments from the posttest; however, he elaborates the argumentation about economic losses due to wolves by the concrete example of fencing. Fencing in livestock is a strategy suggested for ecological management, but as Karl claims; it increases the costs for farmers and is thereby an argument against wolves. There is certainly a qualitative difference in Karl's argumentation between the tests. From a pretest answer based on feelings, his argumentation in the posttest demonstrates that he has done a good job combining and interpreting information from different sources provided in the program, thereby putting forth argumentation that is not easily accessible. In contrast to the pretest, Karl uses terms like predators and food chain in the posttest and the follow-up.

Example 7: Camilla
Question
English: Why are some people against having wolves in Norway? (pretest) Which arguments do people use who are against wolves in Norway? (posttests)
Norwegian: Hvorfor er noen motstandere av at vi skal ha ulv i Norge? (pretest) Hvilke argumenter mot ulv brukes av de som er motstandere av ulv i Norge? (posttest)

Pre-test:	***Post-test:***	***Follow-up:***
English		
Because they think that they are dangerous or threatening for e.g. their flock of sheep.	*They kill the farmers' sheep, the farmers economy will weaken. Wolves <u>have</u> killed humans, it <u>can</u> happen again and it is terrible that people living close to wolf areas have to live in fear now. We can do something about it.*	*Wolves have killed (humans) and can do it again. The wolf population is increasing. Wolves eat the farmers sheep.*
Norwegian:		
Fordi de mener de er farlige eller er truende for for eksempel saueflokken deres.	*De tar sauene til bøndene, bøndene får verre økonomi. Ulven <u>har</u> drept mennesker, det <u>kan</u> skje igjen, og det er forferdelig at de som bor i nærheten av ulv skal leve i frykt nå. Vi kan gjøre noe med det.*	*Ulven har drept (menesker) og kan gjøre det igjen. Ulvebestanden vokser stadig. Ulver spiser sauer til bøndene.*

Camilla's argumentation in the pretest is based on feelings. In the posttest her argumentation is still dominated by feelings, but she uses a more elaborated argumentation, since she now is familiar with information about the fact that wolves actually have killed humans in Norway. In the follow-up Camilla repeats the argumentation about danger and fear, but she also introduces a new argument against wolves: the wolf population is increasing - a problem for farmers since wolves kill their sheep. Camilla's argumentation in the tests is dressed in an emotional language, and this also reflects some of the argumentation held by stakeholders against wolves. Camilla's and Karl's answers on the tests sum up the most important arguments used against wolves:

- *Wolves kill sheep and cause economic loss to farmers*
- *Wolves have killed people and can do it again*
- *Wolves kill more sheep per individual wolf than other predators*
- *Wolves are on the top of the food chain, therefore the influence on other species is minimal if wolves are driven to extinction*
- *People in wolf areas are living in fear*
- *The wolf population is increasing*

As we can see, there is a difference in the types of arguments used for and against wolves. The arguments used for wolves seem to be based on the biological value of the wolves and the commitment to the Bern convention to protect endangered species. In addition many arguments for wolves are counter-arguments to those against wolves. On the other hand, arguments against wolves seem to be based on the danger of wolves to humans and livestock, and the economic consequences of having wolves in the Norwegian wilderness.

To what extent did working with the wolf program influence the students view on wolves?

The wolf conflict in Norway is regularly put on stage by the media. However, the media often tends to present views of just one side in the conflict, something that might influence public opinion. Results from a survey on attitudes toward wolves in four counties in South-eastern Norway shows that about 50% of the sample express various degrees of fear for wolves (Bjerke & Kaltenborn, 2000). One of the intentions with the Viten wolf program is to provide a more balanced view of this conflict. To evaluate whether the wolf program has influenced the way students think about this issue, we asked the students about their opinion as to whether wolves are dangerous or not. 12 of the 38 students did not change their view from pretest to follow-up. Three of these 12 students thought that wolves are dangerous, while the 9 other students thought that wolves can be dangerous under specific circumstances. Einar is an example of a student that did not change his view on the danger of wolves. As shown in example 8, his answers on the three tests are almost identical.

Example 8: Einar

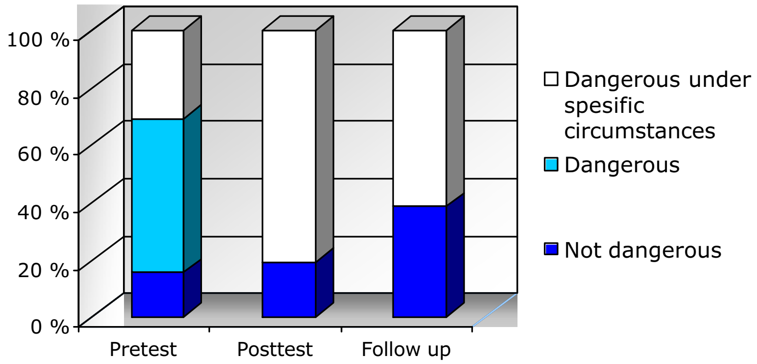
Question

English: Much has been written about wolves lately. Are wolves dangerous or not? What is your opinion?
Norwegian: Det har vært skrevet mye om ulv i det siste. Er ulven farlig eller ikke? Hva er din mening?

***Pre-test*:**	***Post-test:***	***Follow-up:***
English		
Wolves can be dangerous when they are in a pack and haven't eaten for many days/weeks. I'm not afraid of the wolves	*Wolves are not dangerous. Wolves are actually shy to humans, but they can attack people if they are in a pack and haven't eaten for several weeks/days.*	*Wolves are not dangerous to humans. They can be dangerous if you tease them.*
Norwegian:		
Ulven kan være farlig når de går i flokk og ikke har spist på mange dager/uker. Jeg er ikke redd ulven.	*Ulven er ikke farlig. Ulven er egentlig sky for mennesker, men den kan gå til angrep på mennesker hvis ulven går i flokk og ikke har spist på flere uker/dager.*	*Ulv er ikke farlig for mennesker. Den kan være farlig hvis du terger den.*

On the other hand, 26 of the 38 students did change their opinion as to whether the wolves are dangerous from pretest to follow-up. As shown in figure 3, all the students who claimed that wolves are dangerous in the pretest have actually changed their answers in the posttest and follow-up, where most of them are claiming that wolves are dangerous under specific circumstances. Another interesting feature is that the number of students thinking that wolves are not dangerous increased from posttest to the follow-up.

Figure 3: *How students changed their opinion regarding the danger of wolves from pretest to follow-up. N=26.*



The following example shows how Maria changed her answer during the different stages of the teaching sequence.

Example 9: Maria
Question
English: Much has been written about wolves lately. Are wolves dangerous or not? What is your opinion?
Norwegian: Det har vært skrevet mye om ulv i det siste. Er ulven farlig eller ikke? Hva er din mening?

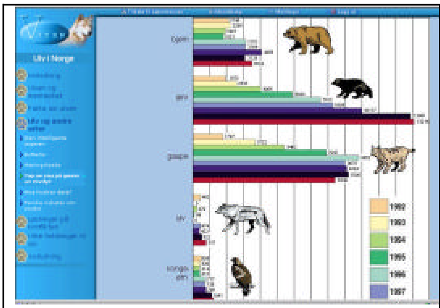
Pre-test*:*	***Post-test:***	***Follow-up:***
English		
Wolves are dangerous to humans and to sheep. I think of wolves as a little bit dangerous, perhaps. Everything you see on the news and so on. But I think it is wrong that people kill them. They are nice when they are tame.	*I mean that wolves are not dangerous!! At least not to humans. It is unusual for wolves to attack people. The most serious incidents are adaptation, rabies, (but rabies do not exist in Norway any more), provocation and environments with little or no regular prey. There have not been any people killed by wolves in Norway for more than 200 years. Of course people get scared if they meet a wolf, but wolves are more afraid of us!!*	*Wolves are not dangerous. Wolverines kill more sheep than wolves, so why do wolves always gets the blame?!?! Many people are afraid of wolves, but they have not killed a single human in Norway for the last 100 years.*
Norwegian:		
Ulv er farlig for mennesker og for sau. Jeg forbinder ulv som litt farlig, kanskje. Alt det man har sett på nyhetene osv… Men jeg synes at det er galt at folk dreper dem. De er snille når de har blitt tammet opp.	*Jeg mener ulv ikke er farlig!! Hvertfall ikke for mennesker, det er uvanlig at ulv angriper mennesker, De største hendelsene er tilvenning, rabies (men det finnes ikke lenger rabies i Norge), provokasjon og miljø med liten eller ingen naturlige byttedyr. Det er 200 år siden noen har blitt drept av ulv i Norge. Det er klart at man blir redd hvis man møter en ulv, men det er ulven som er redd oss!!*	*Ulven er ikke farlig. Jerven har drept flere sauer enn ulv, hvorfor er det ulver som får mest skylden da?!?! Det er mange som er redde for ulv, men de har ikke tatt et eneste menneskeliv i Norge de siste 100 år.*

In the pretest she thinks that wolves are dangerous to sheep and humans, and indirectly she bases this view on what has been said about the issue in the media. In the posttest Maria has changed her opinion towards the danger of wolves. She starts by claiming that wolves are not dangerous, but from the rest of her answer it is clear that she modifies this claim by pointing to specific circumstances where wolves are dangerous to humans. Therefore we have classified this answer as dangerous under specific circumstances. Her answer in the posttest is also much more elaborate compared to the pretest and her argumentation is based on information presented in a research report on the danger of wolves. In her follow-up she says that wolves are not dangerous; and in contrast to the posttest, she doesn't provide information of situations where wolves actually can be dangerous to humans. We thereby classified her answers as not dangerous. Like Maria, most students who changed their answers from claiming that wolves are dangerous to dangerous under specific circumstances refer to information found on a page with a research report about the danger of wolves, see Table 3. When Maria in the follow-up argues that wolves are not dangerous she is backing her claim with information that other predators kill more sheep than wolves. Hence Maria's argumentation can be traced back to a page with statistical information about the bss of sheep to predators, see Table 4.

Table 3: *Page with a research report about the danger of wolves.*

	Aims for the page	*SKI principle 1 and 3*
	▪ *This summary of a research report is meant to give students factual information of how dangerous wolves really are to humans.* ▪ *Promote discussion about this issue in the student dyad.*	▪ *Scientific research about the danger of wolves is made accessible to the students.* ▪ *Students can learn from each other by discussing the given information.*

Table 4*: Page with statistical information about the loss of sheep due to predators.*

	Aims for the page	*SKI-principle 3 and 4*
	▪ *Students should learn to read and interpret information from graphical sources.* ▪ *Students should learn factual knowledge about the relationship between the sheep and the predators.* ▪ *Promote discussion about this issue in the student dyads.* ▪ *Students should be able to use information from this page when arguing in the debate.*	▪ *Students can learn from each other by discussing the given information.* ▪ *Practice in using information from graphical sources promotes autonomous learning.*

Differences in the responses of girls and boys?

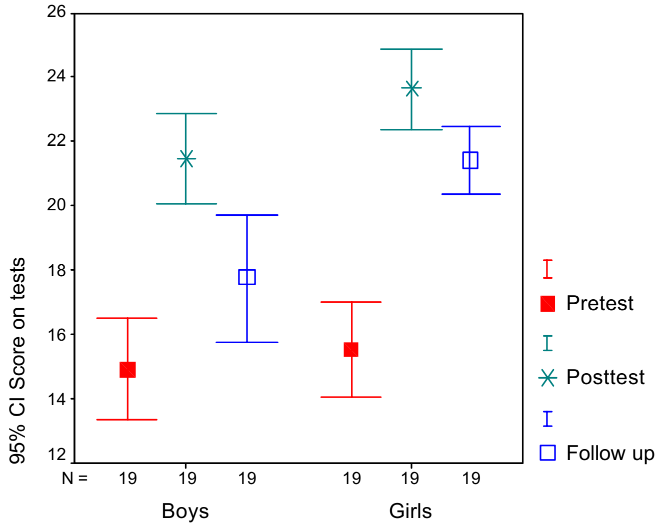
Under classroom observations during the teaching sequence our impression was that girls spent more time on most activities than boys. A recently developed feature of the Viten platform made it possible to document the amount of time that each dyad spends on individual pages within the wolf program. We found gender differences in mean time spent on the computer-based part of the program, with girls spending more time than boys, see Table 5. The number of girls spending more than 180 minutes on the wolf program is significantly higher than the number of boys (P<0.001), one-sample t-test. Our observations and teacher interviews support this data. Teachers commented that girls worked more systematically and discussed more as compared to boys.

Table 5: *Gender differences in time spent on the wolf program.*

Time spent using the wolf program	***Total***	***Boys***	***Girls***
Number of students spending less than 90 minutes	*2*	*1*	*1*
Number of students spending between 90-180 minutes	*42*	*26*	*16*
Number of students spending more than 180 minutes	*12*	*0*	*12*

Finding this gender difference in time spent on the computer-based part of the program we were curious to investigate whether this influenced the students' achievements on tests. As indicated in figure 5, there are no significant differences between gender in scores on the pretest. However, girls have a statistically significant higher score than boys on the posttest (p=0.022), t-test for independent samples. There is also a statistically significant difference in favour of the girls in score on the follow-up test (p=0.002), t-test for independent samples. These findings indicate that students spending more time on the different activities in the wolf program absorb more of the content and also have a higher degree of retention.

Figure 5: *Gender differences in score on achievement tests.*



DISCUSSION

In this study, we set out to evaluate the effectiveness of the Viten wolf program in meeting the aims of teaching about the biology of wolves, about ecological management and the controversial issue of wolves in Norway. In addition, we also wanted to find out whether the teaching sequence influenced students' views on wolves, and whether there were any gender differences in the responses to the program.

Learning gains achieved

As expected, the students scored significantly higher on the posttest compared to the pretest. It is interesting to notice that even after four months, students continued to demonstrate high levels of retention. Not surprisingly, the results also showed that most students lost some of their arguments during the period from the posttest to the follow-up test. The extent to which this happened varied, of course, between the individual students. However, the follow-up tests and student logs have convinced us that the students became genuinely involved in this conflict and retained information about the different aspects of it even weeks after completion.

Of the questions common in the three tests, all of the 10 multiple-choice questions were about the biology of wolves. A majority of the students had 7-10 correct answers on multiple-choice questions at the follow-up, even though one might think that details (see appendix) could be quickly forgotten.

In taking a closer look at the answers to open-ended questions, we found a general pattern amongst the students to give more elaborated answers in the posttest. Typical answers in the posttest were recognized as suggestions or claims backed up by examples or reasoning. Overall the posttest answers were more specified, and the students used concepts like predator, population and the Bern convention, in contrast to the pretest answers that were found more general and based on feelings. Another general feature in students' answers was that they lost some of the examples and reasoning between posttest and the follow-up.

On the basis of our results we make the claim that students score higher on the achievement tests after completion of the Viten wolf program, and even after four months students continue to demonstrate high levels of retention. There is a qualitative difference in the students' answers to open-ended questions before and after the work with the Viten wolf program: the posttest answers are more specific, contains examples, claims are often backed up by reasoning, and the students use biological concepts like predator, prey, population and rabies in contrast to the more general pretest answers that are often dressed in an emotional language.

When we asked students about where in Norway one finds wolves today, we were struck by many student answers that did not recall the areas by their names. Many students explained where on the map one could find these areas, with some students even drawing a map to locate the wolf areas. As curriculum designers this tells us that visualisations are important since the activity provided in the program concentrated on map locations. At the same time, however, we are also aware that our map should provide the names of geographical areas so that this information might also be included in student responses.

Students were asked to suggest strategies for ecological management, and we were surprised to learn how little our student population actually knew about the wolf controversy and ecological management before starting the program since it is so visible in the Norwegian media. A general feature in responses to questions related to these issues was limited or lacking answers on the pretest, with more elaborated answers on the posttest. Since one of the overall objectives for the Viten wolf program is to allow students to participate in an offline debate about the wolf controversy, we were interested in to what extent the students were able to identify the views of the stakeholders in this conflict or use information from the program to construct argumentation for or against wolves. When developing the wolf program, the Viten team was very conscious of providing an approximately equal number of arguments for and against wolves in the program. However, many of the arguments introduced in the program can be used both for and against wolves: e.g. the information about the small size of the Scandinavian wolf population. Such an argument is used for the protection of wolves as an endangered species and backed up by the fact that Norway is committed to the Bern convention. In contrast this piece of information is also used as argumentation against wolves since it shows that the wolf population is slowly increasing. However, there are differences in the types of arguments suggested for and against wolves. The arguments used for wolves seem to be based on the biological value of the wolves and the commitment to the Bern convention to protect endangered species. In addition many arguments for wolves are counter-arguments to arguments against wolves. On the other hand, arguments against wolves seem to be based on the danger of wolves to humans and livestock and the economic consequences of having wolves in the Norwegian wilderness.

Not surprisingly the type of arguments suggested for and against wolves reflects arguments used by the stakeholders in the actual wolf debate in the Norwegian society.

We have also seen examples that students are able to interpret and combine different information sources to construct argumentation that is otherwise not easily accessible in the wolf program.

How did working with the wolf program influence students view on wolves?

Due to the fact that wolves historically have posed a threat to human safety it is easy to understand why we have a "cultural fear" of wolves, which is reinforced through stories and mythology. Recent surveys in Norway indicate that fear of wolves is still widespread among people even though the wolf population has been extremely small during recent decades and nobody has been killed or injured for 200 years. Only 10% of Norwegians accept that wolves should live within 5 km of their home, 48% answer that they are "slightly afraid of wolves". However it is important to remember that there is a clear majority of Norwegians in favour of wolves existing in the country (Linnell & Bjerke, 2002).

The attitude that people in general have towards wolves is also influenced by their confidence in different sources of knowledge (scientific knowledge versus lay knowledge). Those with confidence in scientific knowledge are likely to be more positive towards wolves; however large parts of rural communities have low confidence in this source of knowledge. There has been a conflict between lay knowledge and scientific knowledge with regards to the danger wolves pose to human safety (Linnell & Bjerke, 2002). One intention with the Viten wolf program was to provide information that supports a balanced view of the wolf conflict in Norway. Finding out to which extent the wolf program had influenced the students' ways of thinking about wolves was therefore of particular interest in this study.

Two thirds of the students actually did change their opinion towards the danger of wolves after working with the Viten wolf program. Half of these students thought that wolves were dangerous at the pretest. At the posttest and follow-up these students had modified their answers and claimed that wolves are dangerous under specific circumstances.

So, what is it that made these students change their view on the danger of wolves? By looking in detail at the individual student answers, we find some common traits in their argumentation. It seems that most of these students have constructed their new argumentation on the basis of two particular pages in the Viten wolf program, see Table 3 and 4. One of these pages is a research report on the danger of wolves. In this report researchers have identified four factors that are associated with wolf attacks on humans: rabies, habituation, provocation and extreme socio-economic environments. A summary of incidents where wolves have attacked humans is also provided in this report. All or parts of this information are frequently used in the students' argumentation about the danger of wolves. The other page often referred to by students contains statistical information about the loss of sheep to predators. The graphical information provided on this page is shocking to most Norwegian students. It seems that the media only write about wolves killing sheep and therefore the general public is quite unaware of other predators in the Norwegian wilderness. Even golden eagles have killed more sheep than wolves have, in the last decade. On this page, one can also find information about the fact that 75% of sheep that die while grazing die for other reasons than predators.

Another interesting feature of students' views on wolves is that the number of students thinking that wolves are not dangerous increased from the posttest to the follow-up. This can be due to several reasons e.g. that the students have forgotten under which circumstances wolves could be dangerous. Another possibility is that students have continued paying attention to this issue and changed their mind due to new evidence.

Our results show that the Viten wolf program did change the ways students are thinking about the danger of wolves. It seems that two particular pages with research-based scientific information had the strongest influenced on the students' opinions regarding this issue. Our results are also in line with recent surveys on peoples' attitudes towards wolves in Norway reporting that people with confidence in scientific knowledge are likely to be more positive towards wolves than others (Bjerke, Skogen, & Kaltenborn, 2002).

Were there any gender differences in response?

The girls in this study spend more time working with the online part of the wolf program than the boys. The girls also have significantly higher scores on posttest and follow-up compared with the boys in this study. These findings indicate that students spending more time on the different activities in the wolf program absorb more of the content and also have a higher degree of retention. It is interesting to view these findings in light of the results of Program for International Student Assessment (PISA) which reports large gender differences in reading competences in favour of girls in Norway (Lie, Kjærnsli, Roe, & Turmo, 2001). If it is so that girls are better readers, spend more time on the activities in the program and have higher scores on the achievement tests, then we have something to learn from this information. It would be interesting to follow-up these results more systematically in a study with a larger sample.

Our impression from classroom observations and students' individual logs does not suggest a gender difference in motivation and engagement for working with the wolf program. Both girls and boys seemed very motivated and engaged during this teaching sequence. Several students have commented in their logs that they enjoyed learning about the wolf controversy, and that they thought the work gave them useful information. Two students had the following comments in their logs:

”It has been fun to become engaged in the wolf debate and form my own opinion. Now that I know more facts about wolves, I can also contribute and come with arguments if the wolf controversy is discussed”

”I hope we are going to have more projects on the computer. It makes learning more fun, and we will probably be needing ICT skills later in life.”

CONCLUSION

From student logs and their engagement when working with this teaching program, we know that the students love using the computers for learning. We are surfing on a wave of new methods that fits very well into youth culture. But are they learning science?

On the basis of our results we make the claim that students score higher on the achievement tests after completion of the Viten wolf program, and also demonstrate high levels of retention after four months. There is a qualitative difference in the students’ answers to open-ended questions before and after the work with the Viten wolf program and we have also seen examples that students by interpreting and combining different information sources are able to construct argumentation that is not easily accessible in the wolf program.

Our results show that the Viten wolf program did influence the ways students are thinking about the danger of wolves, with 2/3 of the students changing their opinion about the danger of wolves.

This study further shows that there are statistically significant gender differences in time spent on the online part of the wolf program, and we suggest that these differences seem to influence students’ achievement on the posttest and also on the follow-up after four months.

We are just starting to understand the effects of learning environments such as Viten. The wolf program provides a mixture of information and activities, allowing student dyads to make their own selections of information and construct their own texts in the electronic workbooks. As curriculum developers in this new medium, we are integrating our knowledge of science together with information technology and pedagogy. The challenges are many, and not all easy to solve. However, when we are able to show positive learning gains, together with enthusiastic students, eager to learn science, we feel as though we are on the right track. Given what we have experienced from this study the next step on our research will involve a focus on construction and evaluation of arguments. We are working on a paper evaluating student argumentation in the offline part of the wolf program, the classroom debate. We are also preparing a revision of the wolf program, where we focus even stronger on construction and evaluation of argumentation.

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APPENDIX

Table x: *Multiple choice questions common in all three tests.*

What does the word prey mean? *a. An animal that is captured and eaten by another animal.* *b. An animal that can be exchanged with another animal.* *c. An animal that competes with another animal.* *What is the most important food for wolves?* *a. The deer (cervidae family)* *b. Sheep* *c. Gras* *How far is an adult wolf able to travel in 24 hours?* *a. 2 km* *b. 20 km* *c. 200 km* *What is a predator?* *a. A plant eating animal* *b. A meat eating animal* *c. An animal that catches and eats its prey.* *What is meant by territory?* *a. An area that is actively defended against intruders of the same species.* *b. An area where wolves stay during the night.* c. *An area where the government has given the wolves permission to live.*	*What are domestic animals?* *a. Animals that live together with humans, and/or are not afraid of humans.* *b. Animals that can take care of themselves in nature.* *c. Animals that prefer to stay indoors.* *How many cubs are usually in a wolf litter?* *a. 1* *b. 7-9* *c. 3-6* *Why do wolves howl together?* *a. To scare humans* *b. To strengthen the feeling of unity in the flock* *c. To attract other wolves* *How many wolves are there in Norway today?* *a. 10-50* *b. 100-200* *c. 300-500* *How many people have been killed by wolves in Norway during the last century?* *a. 0* *b. 2-3* *c. 7-8*

Table x: *Overview of all the open-ended questions on the three tests. The bold questions are not common in all the three tests.*

Pretest
1. Write four sentences you think about related to wolves.
2. A lot has been written about wolves lately. Are wolves dangerous or not? What is your opinion?
3. Why do some people want us to have wolves in Norway?
4. Why are some people against wolves in Norway?
5. Who do you think should decide whether we should have wolves in Norway?
6. What type of habitat is most preferred by wolves?
7. Where in Norway do we find wolves today?
8. Why do wolves usually live in packs?
9. What is an alpha pair? (Multiple-choice question on the other tests)
10. There is a conflict in Norway about whether or not we should have wolves. Do you have any suggestions for how wolves and people can live in the same areas?
Posttest
2. Are wolves dangerous or not? What is your opinion?
3. Which arguments are used by those who want us to have wolves in Norway?
4. Which arguments are used by those who do not want us to have wolves in Norway?
5. Who do you think should decide whether we should have wolves in Norway?
6. What type of habitat is most preferred by wolves?
7. Where in Norway do we find wolves today?
8. Why do wolves usually live in packs?
10. Do you have any suggestions for how wolves and people can live together in the same area?
11. What is the Bern convention?
12. How do wolves defend their territories?
13. What is the composition of a pack of wolves? (Number of individuals? Which individuals?)
14. Mention four things about wolves that you didn't know until you started working with the Viten program.
Follow up
2. Are wolves dangerous or not? What is your opinion?
3. Which arguments are used by those who want us to have wolves in Norway?
4. Which arguments are used by those who do not want us to have wolves in Norway?
5. Who do you think should decide whether we should have wolves in Norway?
6. What type of habitat is most preferred by wolves?
7. Where in Norway do we find wolves today?
8. Why do wolves usually live in packs?
10. Do you have any suggestions for how wolves and people can live together in the same area?
11. What is the Bern convention?
12. How do wolves defend their territories?
15: What do you think about the population size, i.e. the number of wolves in Norway today? Should it be maintained as it is, or is it too high? Or too low? Give reasons for your answer.
16. You move to a place in Norway where they are going to build a new road. The people in the area do not agree about the new road because it is supposed to go through a valuable area for outdoor activities with several rare animal species. Therefore the city council has decided to arrange a referendum about the building of a new road. What will you do to collect information to give the right vote in the referendum?

Paper II:

Mork, S. M.: A Case Study of Design and Implementation of the Web-based Viten Program *Radioactivity*. Manuscript

Design and Implementation of the Web-Based Viten Program *Radioactivity*

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Abstract

Information and communication technology (ICT) has become a natural part of most people's everyday life, and has also been introduced in schools. After having focused on obstacles like lack of hardware and software, and lack of computer skills among teachers, the focus has now turned more towards how ICT best can be exploited to promote learning. This paper explores learning material from the Norwegian Viten project which develops web-based learning materials in science for grades 8-12. In this paper, the Viten program *Radioactivity* is investigated in order to provide insights into how features of the program influence implementation and student learning. Using a pretest-posttest design, data from a classroom study involving four classes of 10^{th} grade students working on *Radioactivity* is evaluated. A characteristic of the features of *Radioactivity* is provided and discussed in light of student achievements and student opinions on the web-based program.

Introduction

We live in a digitalized society where ICT has become almost omnipresent, and plays an increasingly significant role in both our private and working lives. ICT is also present in schools, but there have been many obstacles for successful implementation, such as lack of hardware, infrastructure, access to educational software, and ICT pedagogical skills amongst teachers. It has been suggested that with the presence of ICT; complex systems can be simulated, the curriculum can be centred on "authentic" problems parallel to those that adults face in real-world settings, modelling and visualisation can be used to bridge between experience and abstraction, and controversial topics may be discussed with experts and outside the immediate classroom (Dede, 2000; Crosier, Cobb, & Wilson, 2002; Jorde, 2003). The idea that using ICT enhances student motivation has gained currency in recent years (Campbell, 1984; Rieber, 1991; Schofield, 1995; Strømme, 2004), hence Schofield (1995) suggests a range of potential reasons such as novelty value, variety from teachers' lecturing, usefulness of ICT-skills later in life, challenge of ICT applications as compared to ordinary school work, differentiation as students are in control and can work at their own pace, and finally, some ICT tools provide rapid feedback.

Studies of the use of ICT in educational settings have focused on issues like design, change of classroom practice and learning outcome (Ludvigsen & Østerud, 2000; Wasson & Ludvigsen, 2003; Hoffman, Wu, Krajcik, & Soloway, 2003; Songer, Lee, & McDonald, 2003; Furberg & Berge, 2003; Clark & Jorde, 2004). According to Erstad (2004), there is a tendency that research on implementation of ICT in schools has moved from a strong technology-based focus e.g. registering number of computers, and amount of time spent using ICT in schools (Quale, 2000; Kløvstad & Kristiansen, 2004; UFD, 2005) towards focusing more on how technology best can be exploited to promote learning. Based on a literature review, Webb (2005) argues that ICT-rich environments in science teaching can: 1) promote cognitive development, 2) enable a wider range of experience, so that students can relate science to their own and other real-world experiences, 3) increase students' self-management, and enable them to track their progress, so that teachers' time is freed to focus on supporting and enabling students' learning; and 4) facilitate data collection and presentation of data that help students to understand and interpret the data.

Lottis (2002) suggests that evidence about the effectiveness of particular technology-based approaches must be gathered, evaluated, analysed and published. Similarly Crosier et al. (2002), suggest that school-based evaluation studies are important for gaining an understanding of how software is used and integrated in school settings. They further argue that observing students using the software and gathering their opinions of it will ensure that the software is useful, enjoyable, and usable by students, and that the educational goals are being satisfied. Such a line of research is followed in the present study on the design and implementation of the digital teaching program *Radioactivity,* from the Norwegian Viten[1] project. The Viten project has connections to the WISE-project[2] (Linn & Hsi, 2000; Linn, Clark, & Slotta, 2003; Jorde, Strømme, Sørborg, Erlien, & Mork, 2003; Linn, 2003) and is developing digital learning materials in science for students in grade 8-12. Since launching

[1] The word **viten** means **knowledge** in Norwegian
[2] http://wise.berkeley.edu

the Viten web-site[3] in 2002, a total of 63 083 unique students are now registered as users of the Viten teaching programs. *Radioactivity* is the most popular Viten program with 25 586 registered users by June 22, 2005. The present study focuses on the following research questions:

1) *What features of Radioactivity are likely to have an impact on student learning?*
2) *What are students actually learning when using the Viten Radioactivity program?*
3) *What are student's opinions about the Viten Radioactivity program?*

Radioactivity in schools

Why teach about radioactivity?

Radioactivity is repeatedly mentioned in the media, for instance, regarding consequences of Chernobyl, radon[4] in houses, and the radioactive waste from Sellafield[5], a major reprocessing plant which is located on the northwest coast of England. Hence, radioactivity is an area of science that is of continued public interest and concern, and should therefore be addressed in science education. Millar (1994) suggests that from a perspective of "democratic utility" many people would give high priority to understanding the phenomenon of radioactivity and ionizing radiation, because of links to such issues as nuclear power and the risks of exposure to ionizing radiation. Similarly, Henriksen (1996) points to three main arguments for possessing knowledge about radioactivity:

- ***The pragmatic reason:*** *People should be capable of protecting themselves from the harmful effects of radiation as well as avoiding excessive fear.*
- ***The democratic reason:*** *People should be capable of informed judgements in political matters involving radiation phenomena: nuclear energy, waste disposal, exposure limits etc.*
- ***The educational reason:*** *The individual derives pleasure and fulfilment from knowing something about the world around him/her.*

[3] viten.no
[4] In June 2005, the World Health Organisation (WHO) raised the alarm that radon is the second most common reason for lung cancer after smoking. Norway has the world's highest concentration of radon indoors.
[5] The content of the radioactive discharges from Sellafield can be traced from the Irish Sea north to the coast of Norway and up to the Barents Sea, reaching as far north as Spitsbergen. The largest concentrations of radioactivity may be found along the coastline off the Sellafield site itself. Radioactive contamination has been traced in shellfish, fish, and seaweed, to ocean water, sediments on the bottom of the Irish Sea and in sand on the beaches.

Millar (1994), argues that because of the historical role radioactivity played in developing ideas about the structure of matter, the topic has a strong claim to inclusion in the science curriculum, both on "cultural" grounds and from the more traditional perspective of the logical structure of the discipline. In contrast, Eijkelhof (1996) argues that if the main aim of science education is to prepare students for coping with life in modern society, the purpose of teaching the topic of ionising radiation should be shifted from "understanding nuclear physics", to "being able to understand radiation risk information". He further suggests that this should influence curriculum content and teaching strategies.

What do we know about the understanding of radioactivity? Compared to physics topics like electricity or mechanics, relatively little research has been carried out on students' and the public's conceptions of radioactivity. However, a number of studies regarding understanding of radioactivity have been done after the Chernobyl accident in 1986. One line of focus has been ideas that students and the general public have on radioactivity in relation to information presented in the media (Eijkelhof & Millar, 1988; Lijnse, Eijkelhof, Klaassen, & Scholte, 1990). Lijnse et al. (1990) argue that there is a striking correspondence between student ideas and media information after the Chernobyl accident. They report that many people have an undifferentiated concept of radiation/radioactive matter. People seem to grasp fragments of information from the media and create their own conceptions on radioactivity. Stølsbotn (2002) found that 23% of a sample of the Norwegian population regarded it as true, or probably true, that if someone is exposed to any amount of radioactivity, they are certain to die as a result. A view of radioactivity as something dangerous seems to be quite common. Sjøberg (2004) talks about "radio-phobia": a fear for all that resembles nuclear physics, atoms, and radiation – at least when the radiation is made by humans. He argues that in medicine, for instance, we no longer talk about *Nuclear Magnetic Resonance* (NMR), but rather forget *Nuclear* and use the notion *Magnetic Resonance* (MR), which does not sound dangerous, but denotes the same thing (ibid).

Other studies, across different age groups, nationalities and educational levels, suggest that people have an undifferentiated understanding of concepts like radiation, radioactive material, irradiation, and contamination (Millar, 1994; Klaassen, 1995; Millar & Singh Gill, 1996; Henriksen, 1996; Alsop, 2001; Henriksen & Jorde, 2001). Hence, radioactivity is a phenomenon that seems difficult for students and the general public to understand. What can be done to improve young peoples' understanding of radioactivity?

Approaches to teaching about radioactivity in schools

Radioactivity is taught in secondary school science classes all over the world. According to several researchers (Millar, Klaassen, & Eijkelhof, 1990; Eijkelhof, 1996), the usual approach to radioactivity has been to start with the structure of the atom and the nucleus, followed by concepts such as half-life, a, ß, and ? radiation, activity, nuclear fission and fusion. Towards the end of the series of lessons, some applications are usually mentioned, such as irradiation of food, and nuclear power plants, while safety issues are dealt with only superficially. Other ways of teaching about radioactivity have been suggested. Millar et al (1990) proposed an approach based on research into children's understanding about radioactivity, set in a real world context with the micro-level explanations at the end of the teaching sequence. Parts of this are followed up in the pilot resources for the *21st Century Science* (Holman, Hunt, & Millar, 2004). Klaassen (1995) developed a problem-posing approach, not based upon micro-level explanations. Henriksen and Jorde (2001) reported that visiting a museum exhibition as part of the teaching sequence, provided science learning outcomes for the majority of the students when investigating high school students' understanding of radiation. Crosier, Cobb, and Wilson (2000; 2002) developed a virtual environment for teaching about radioactivity, and observed no clear benefits for the virtual environment compared to traditional teaching methods in terms of test scores and attitude ratings. The present study also reports on an approach using ICT for teaching about radioactivity. Due to the nature of radioactivity as an "invisible" phenomenon which is difficult for many students to understand, ICT may serve an important role in making the "invisible" visible. Many Norwegian schools do not have equipment like Geiger counters and Scintillation counters, and many science teachers have not studied physics and may feel insecure when teaching about radioactivity. Hence, ICT might be useful in providing opportunities for experiments with equipment not available in all schools.

Features of the Viten Radioactivity program

This section will provide a description of the aims and features of the Viten program *Radioactivity*. The main aims of *Radioactivity* are identical with the Norwegian national curriculum goals for secondary school science, 10th grade (KUF, 1996b):

Substances, properties and use:
"Pupils should have the opportunity to learn about the characteristics of various types of radioactivity, radioactive substances and minerals, and the use of radioactive substances and their usefulness to society set against their health and environmental hazards. Access to software may be helpful in this connection"

The program also covers some national curriculum goals for grade 11. *Radioactivity* is based on well accepted, current theory about radioactivity[6]. However, the novelty of the present approach on radioactivity is the placing of the topic in a context where the students are given roles as journalists with a case to solve. The teaching program is organized in a specially designed learning management content system (LMCS), with a menu on the left hand side (see Figure 1), containing various types of activities.

Figure 1: *The Viten user interface with the menu on the left hand side including main units[7] and sub-units. Student notebook is available on the top, while various activities, evidence units, simulations etc are available in the main window.*

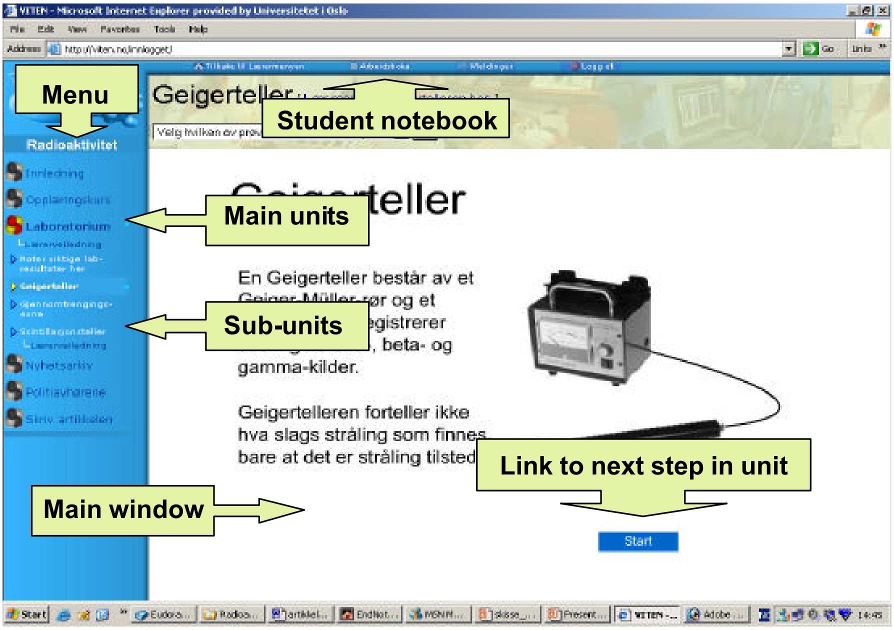


Table 1 provides a detailed description of the six main units of *Radioactivity* and the features of each unit.

[6] In Norway the term "radioactive radiation" is often used, as in the Netherlands (Lijnse 1990).

[7] A ***unit*** is defined as a link that is found in the navigation menu of *Radioactivity*. Each unit may have several steps, and the work load varies between different units.

Table 1: *Description of the six main units in Radioactivity and the features of each unit.*

Main units	Features
Introduction The students are introduced to their mission, which is to take on the role as journalists for an online newspaper. They are going to cover an explosive fire involving a car accident. At the scene of the accident they discover traces of radioactive substances.	-Virtual case where ICT makes it possible to create a scene for students to act on. -ICT makes the case more realistic by keeping the students in the case through virtual cell phone messages from the editor during their work process. - Students can take virtual samples from the scene of the accident. These samples will later be analysed at the virtual lab. -Teacher guidance encourages discussion on how many samples are needed and where these should be taken, e.g. the importance of blind samples, marking samples and taking safety precautions.
Training course Students are introduced to the basics of radioactivity and the three types of radiation, guided by animations, experiments, written tasks and multiple choice questions.	-Animations are used to explain the particle model and the origin and characteristics of a-, ß- and ?-radiation. -"Fill in" tasks where students receive immediate feedback, e.g. to practice understanding of atomic formulas, are included. - A multiple choice test giving immediate response.
Virtual laboratory Students are able to analyse the samples they collected from the scene of the accident by Geiger counter and Scintillation counter. In addition they watch animations of the pervasiveness of the three types of radiation. The objective is to identify the radioactive substances from the scene of the accident.	-Virtual samples can be analysed in three ways: 1) By a Geiger counter showing the radiation activity. 2) The penetrating power of radiation types in paper, aluminium, lead and human tissue. 3) Defining the radioactive substances in the sample by a Scintillation counter and an isotope table. -All tools at the lab are simulations designed as a step by step sequence and supported by text. -Cell phone text message from the editor with questions and encouraging comments.
News archive Contains recent news involving radiation. Students can also find some factual information that may help them solve their case.	-The newspaper articles are fictional, specially designed to support the case in this teaching program.
Interrogations Transcripts from interrogations of the involved parties in the accident are available here. These might help students identify the person who placed the radioactive substance in the cargo.	- A cell phone text message from the editor reminds the students of their deadlines.
Newspaper article Closing activity: the students must evaluate evidence, and complete the mission by writing an online newspaper article. Here they find tips on how to write a factual article and what to include.	-Electronic newspaper where students write their article and publish it when it is accepted by the teacher. -Information on the newspaper article genre and critiquing sources is provided.

The approach chosen in *Radioactivity* connects scientific information that may seem inaccessible for many students, to situations that might happen in their everyday life. When reporting on a fire in a car accident, they discover traces of radioactive substances and pursue the case by collecting information on radioactivity, performing measurements and analyses at the virtual laboratory, and learning how to write a newspaper article with scientific information. The scene of the accident is situated in the mountain area of Dovre, where traces of radioactive substances from the Chernobyl accident are still measurable. When students collect virtual samples, they find traces of radioactive isotopes from Chernobyl. The idea is that students should learn about the consequences such effluents might have on the environment, the geographical range of the effluents, and their effects over time, and half-lives. Students also detect the radioactive substance Americium, originating from smoke alarms in the cargo of a truck involved in the accident. The purpose is to show students that some types of radioactive substances can be useful and thereby, contribute to a more nuanced understanding of radiation. Through simulations and animations in the laboratory, students learn how radioactive substances can be identified. Working on the newspaper article, students are challenged to use their own language in an interactive constructive process to present information according to a real-world situation.

Methods

Sample and procedure

A design with individual pretest, posttest, and delayed posttest was chosen to map student achievement resulting from use of *Radioactivity*. The original sample consisted of 96 10th grade students from four classes: a final sample of 62 students participated in all three tests. Four to six class periods were estimated as necessary to complete the program, but for several reasons, the teachers involved in this study decided to spend four class periods at the computer lab working on *Radioactivity*. Most students worked in pairs at the computers, while the performance tests were answered individually. The pretest was preceded by a one-hour lecture by the teacher, but conducted before the work at the computer lab began. The posttest was conducted directly after the work on the web-based curriculum. A delayed posttest was given two months after the first posttest, to get an indication of retention. Seven multiple choice questions and nine open-ended questions (see Appendix 1), identical on all the tests, were used to compare student answers at different points in time.

Analysis of results

To show an overview of student achievements, the multiple choice questions were given code 1 for right answers and code 0 for wrong answers. A coding scheme (see Appendix 2) was developed for open-ended questions, categorising right answers with codes 1-3, where code 3 represented the highest score, and wrong answers were given code 0. However, the main focus of the analysis is a qualitative approach to two open-ended questions regarding radioactivity as a phenomenon, a resource and a threat.

Inter-rater reliability

The last stage of the data analysis was the inter-rater reliability test. The procedures for coding student responses were explained to a fellow researcher, who then independently coded 25% of the student answers accordingly. Inter-rater reliability showed an agreement of 94%.

Results

Types of units in Radioactivity

The units in *Radioactivity* have different features, able to be classified as one of the following three types:

1) *Visual unit* containing text, pictures and animations
2) *Interactive unit* containing activities like simulations, interactive animations, quizzes and fill in tasks
3) *Written unit* involving written tasks

To investigate how various components in *Radioactivity* are used to provide information related to the curriculum goals, the content of *Radioactivity* was classified as information about radioactivity as a phenomenon, radioactivity as a resource, and radioactivity as a threat. Table 2 illustrates how these content categories, and information related to the case/mission, are distributed according to the three types of units in *Radioactivity*. As illustrated in Table 2, the majority of the visual units are related to information about the case, indicating that a lot of effort is put into developing the case/mission and constructing real-life situations for students.

Table 2: *Overview of how the content categories and information related to the case are distributed according to different kinds of units in Radioactivity. Visual units: N=20, Interactive units N=13, Written units N=8.*

	Phenomenon	Resource	Threat	Mixed content	Information related to the case/mission
Visual units	2	1	0	5	12
Interactive units	12	0	0	0	1
Written units	6	0	0	1	1

The most surprising discovery is that all the interactive units, and the majority of the written tasks, are related to radioactivity as a phenomenon. One unit is specifically related to radioactivity as a resource, and no units are specifically related to radioactivity as a threat. However, information about radioactivity as a resource, as a threat and as a phenomenon is mixed on five visual units. From Table 2 it can be concluded that the main focus in the program is radioactivity as a phenomenon. This is in accordance with how radioactivity traditionally has been taught in Norway, and part of what Millar (1994) refers to as the historical role of radioactivity in developing ideas about the structure of matter.

Student achievement

Figure 2: *Overview of student mean score on performance tests. Seven multiple choice questions and nine open-ended questions were common to all three tests. The maximum score is 34.*

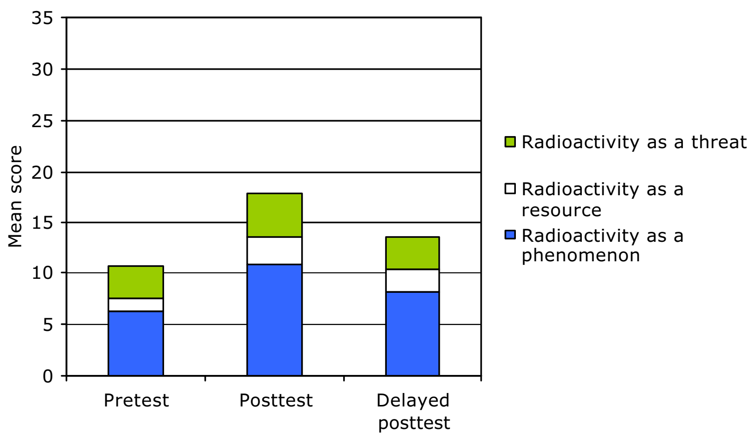


Figure 2 shows an overview of student performance on tests. Student achievement was assessed according to the goals of the national curriculum, focusing on radioactivity as a phenomenon, a resource and a threat.

As expected, there was a significant difference in student performance between pretest and posttest. Also after two months, students scored significantly higher than on the pretest. However, the main focus here is a qualitative analysis of the two open ended questions below:

1. *What is radioactivity?*
2. *Pretest: What are the names of the three types of radioactivity?*
   Posttests: Explain the difference between the three types of radioactivity.

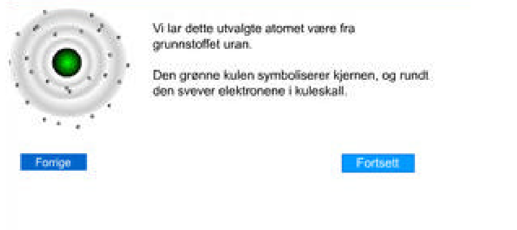
These questions are chosen because they had the most elaborated student answers on the tests and they are both related to radioactivity as a phenomenon which is the main focus of the program. Responses to these questions were categorised according to whether students are able to draw on scientific ideas or whether their answers are incomplete, or drawing on alternative ideas.

1. What is radioactivity?

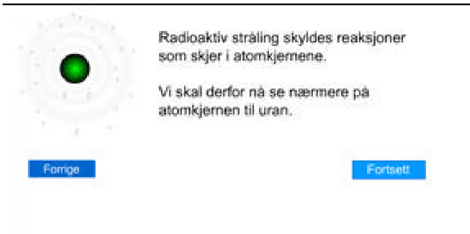
Radioactivity as a phenomenon is introduced through animations and interactive tasks in *Radioactivity*. All these animations are designed according to the same principles: each animation is constructed as a step by step sequence, where students themselves decide when they want to go on to the next step, or whether they want to revisit an earlier stage. Milheim (1993) argues that the fact that learners are sometimes able to control aspects of the animation is a unique feature of animations in computer-based instruction, as compared to animation available in other media formats. Before looking into student answers, a description of one of the animations from *Radioactivity* is provided in Figure 3.

Figure 3: *Step by step of interactive unit on nuclear particles and formulas.*

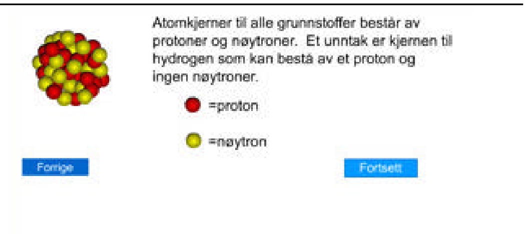
Students are introduced to a part of a substance where the animation zooms in on a model of one atom.



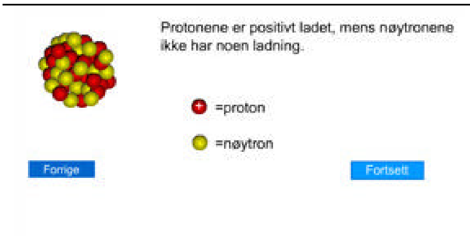
A uranium atom is chosen as an example. The green globe illustrates the nucleus with the electrons moving around it. The blue buttons take the students to the next or previous step of the animation.



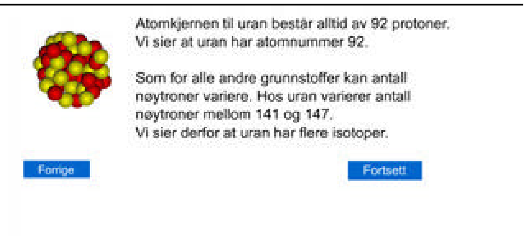
Radioactivity is caused by reactions in the nucleus, so, we shall take a closer look at the nucleus of a uranium atom.



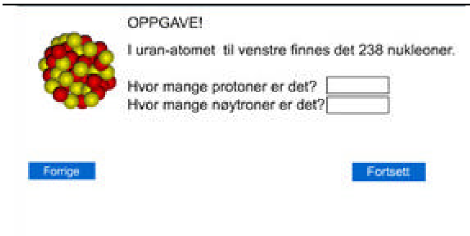
Atomic nuclei in all basic elements consist of protons and neutrons. One exception is the nucleus of the hydrogen atom that may consist of one proton and no neutrons.



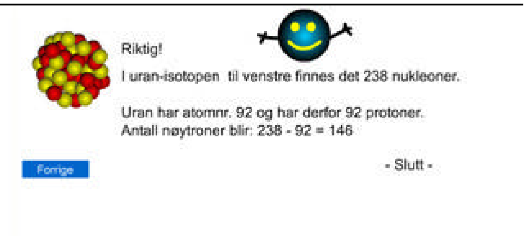
Protons are positively charged, while neutrons have no charge.



Students are introduced to the formulas of atomic nuclei through the example of uranium. They are also introduced to the concept of isotopes.



Students fill in the numbers of protons and neutrons in a uranium nucleus with 238 nuclei.



Positive feedback and a repeated explanation are given when the answer is correct.

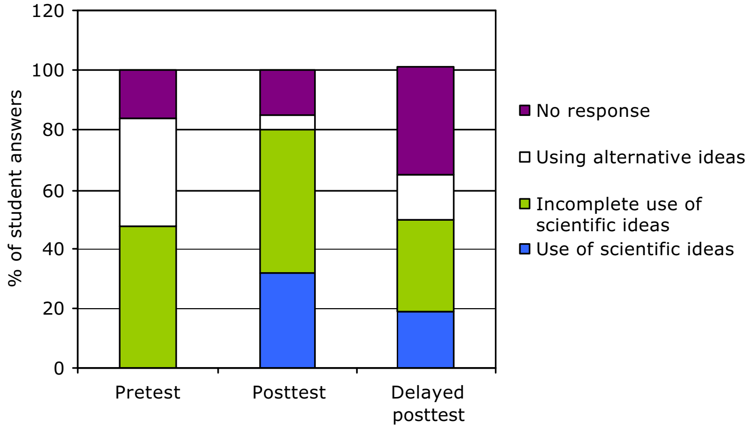
Based on a review of research studies of the effects of animation, Milheim (1993) has developed a series of guidelines for implementation of animation within a computer-based lesson or multimedia program. Three guidelines are related to general design: develop simple animations rather than complex ones, design animation presentations so that important information can easily be perceived, and include options for varying the speed of an animated presentation. The animation in Figure 3 is in accordance with these guidelines since it is simple, includes options for varying the speed, and important information is quite visible.

Milheim (ibid) also provides content-related guidelines: use animation that relates directly to important objectives or features within an instructional lesson, use animation when the instruction includes the use of motion or trajectory, use animation when the instruction requires visualisation, and use animation to show otherwise ”invisible” events. The animations at each step in Figure 3 are certainly related to the objectives of the lesson, they involve motion, and illustrate an ”invisible” phenomenon that may be more easily understood through the use of animation.

To summarise; the animation in Figure 3 seems to coincide well with Milheim’s guidelines (ibid) for implementation of animations. Five other animations in *Radioactivity* are developed after the same principles as the one in Figure 3.

Now, focusing attention on student responses to *“What is radioactivity?”* Figure 4 illustrates that no students were able to draw on scientific ideas about radioactivity on the pretest. On the pretest, the category *using incomplete scientific ideas* contains an overweight of utterances on nuclear power plants, accidents and atomic bombs. On the posttest and delayed posttest, student responses in this category have switched towards focusing on something going on in unstable nuclei.

Figure 4: *Student responses to "What is radioactivity?" N=62. Due to rounding procedures, the sum of percentage is 101 on delayed posttest.*



In the category *using alternative ideas*, students suggest that radioactivity comes from the sun, plane crashes, viruses, electrical devices like cell phones or computers etc. It is encouraging to notice that the proportion of such answers decreases from pretest via posttest to delayed posttest. As expected, the highest proportion of answers using scientific ideas occurs at the posttest. *Use of scientific ideas* includes description of unstable nuclei, alpha, beta and gamma radiation, the effects of the radiation types on humans and the environment, radioactivity as something present everywhere, radioactive waste, nuclear power plants etc. Almost 20% of the student answers are still in this category 2 months after the posttest. The high proportion of no response on the delayed posttest may be due to the fact that this test was conducted just before the end of term and after the final exams in 10th grade. In the following some examples of student answers on pretest, posttest and delayed posttest are presented:

Examples from pretest

It is something that comes from an atomic bomb. When it explodes it sends out radiation and people can die! It can also happen by accidents in nuclear power plants.	This student views radioactivity as something dangerous and associates it with bombs and nuclear power plants. A common feature in many pretest answers. *Coded as Incomplete use of scientific ideas.*
It is quite dangerous radiation from electrical devices e.g. computers.	11% of the students connect radioactivity to electrical devices. *Coded as Using alternative idea.*
It is alpha, beta or gamma radiation and it is added to nuclear weapons to make them more powerful.	This student has heard about the three types of radioactivity, but seems to connect them only to nuclear weapons. *Coded as Incomplete use of scientific ideas.*

Examples from posttest

Radiation is sent out from an atom. This atom has an unstable nucleus and sends out radiation to become stabile. This atom then becomes a new basic element. This new basic element might also be unstable and sends out radiation. An atom can send out radiation only once.

This is a typical example of a posttest answer from this study. *Coded as Use of scientific ideas.*

It is energy that comes from unstable substances without external influence. Three types of natural radiation: alpha, beta and gamma. Alpha: positively charged, consists of two protons and two neutrons. Beta: negatively charged, consists of one electron. Gamma waves: a kind of light, no charge. There are several types and variations of one substance, these are called isotopes. These have more or fewer neutrons in their nucleus and are unstable. They are trying to get rid of the extras to become more stable. They send out either alpha, beta or gamma radiation. When this is done the substance has changed to another and more stable substance.

This student knows that radioactivity is due to unstable nuclei in radioactive isotopes, and can distinguish between the three natural types of ionizing radiation. He is familiar with the concepts of isotopes, electrons, protons and neutrons, and is using them as expected in science. *Coded as Use of scientific ideas.*

Radiation from radioactive substances

Coded as incomplete use of scientific ideas.

Examples from delayed posttest

Radiation that is due to an unstable nucleus.

A typical delayed posttest answer in this study, very brief. *Coded as incomplete use of scientific ideas.*

Radioactive radiation is a product from an unstable nucleus getting rid of parts of the nucleus, an electron or electromagnetic radiation, by doing this; the unstable nuclei get more stable.

This student has a more precise and elaborated answer. *Coded as Use of scientific ideas.*

Radiation that can occur e.g. after exploding an atomic bomb. It can be very dangerous and damage DNA and so on.

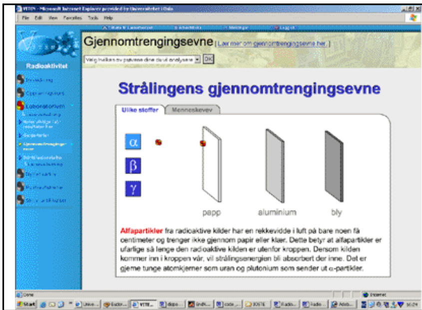
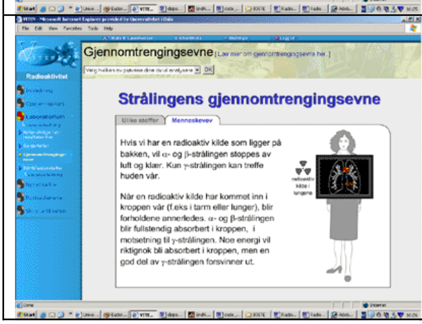
One of the few students in this study that describe radioactivity only as something dangerous on the last test. *Coded as incomplete use of scientific ideas.*

To summarize; the difference between answers to *"What is radioactivity?"* on pretest and posttest seems to be a shift in focus away from viewing radioactivity as solely something dangerous connected to e.g. atomic bombs and accidents at nuclear power plants, towards a more factual description of the phenomenon. This is also reflected in Figure 4, showing the presence of answers drawing on scientific ideas at the posttest. As expected student responses to delayed posttest are less detailed.

2. The difference between the three types of radioactivity

Information about the three types of radioactivity is provided in several animations similar to the one in Figure 3. In addition information about the penetrating power of the three radiation types and their effect on the human body is provided in the animation described in Figure 5.

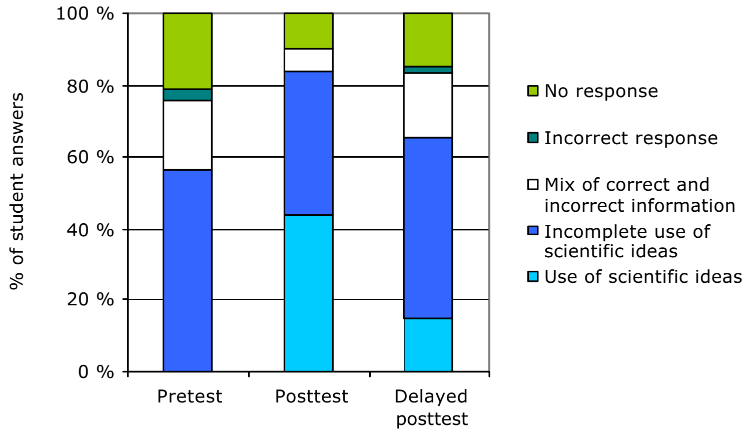
Figure 5: *The unit on the penetrating power of alpha, beta, and gamma-radiation.*

<table>
<tr><td>
</td><td>The penetrating power of the three radiation types. If students hold their pointer over the a, ß, or ? symbol, animated particles or waves representing each type of radiation will appear. Alpha particles will be stopped by the illustrated paper, beta particles will be stopped by the aluminium plate and most gamma radiation will be stopped by the lead plate. At the same time a piece of text below the visualization explains the animation sequence.</td></tr>
<tr><td>
</td><td>The penetrating power of the three radiation types is visualized on the human body. The animation shows how alpha- and beta particles are stopped by air and clothes and how gamma radiation goes through the human body.</td></tr>
<tr><td>
</td><td>This step repeats that alpha- and beta particles from a source on the ground will be stopped by air and clothes. However, it is emphasised and visualized that when a radioactive source has ended up inside the human body, e.g. in the lungs or the intestine the case is different. In contrast to most of the gamma radiation, alpha- and beta radiation will now be absorbed in the human body.</td></tr>
</table>

The animation sequence illustrated in Figure 5 is located in the virtual laboratory in *Radioactivity* and followed by an interactive simulation. In this simulation students cover their samples from the scene of the accident with various materials, and use a Geiger counter to measure the penetrating power of the radiation in each sample.

Let us now focusing on how students explain the differences between the three types of radioactivity. The pretest only asked for the names of the three types, therefore the pretest results in Figure 6 are not directly comparable to the two other tests.

Figure 6: *Student responses to the task: "Explain the difference between the three types of radioactivity" N=62. Due to rounding procedures, the sum of percentage is 99 on pretest and 102 on delayed posttest.*



Student answers classified as *Using scientific ideas* include, and elaborate on, at least two of the following: a) description of the three radiation types, b) their penetrating power and c) electric charge. At the posttest 44% of student answers fell into this category, while at the delayed posttest 15% of student responses were classified in this category. The other categories simply include incomplete, incorrect and a mixture of correct and incorrect descriptions of the same characteristics as in *Using scientific ideas*. Some examples on answers to posttest and delayed posttest follow below:

Examples from posttest

Alpha radiation is negatively charged, cannot go through a thick layer of clothes. Beta radiation is positively charged, can go through the skin. Gamma radiation has no charge, can go through a human being, some of the gamma radiation also goes through a layer of lead.	This student is using scientific terms, knows the names of the types of radioactivity and is familiar with the penetrating power of each type. However, she is confused about the electrical charge of the radiation types. *Coded as Mix of correct and incorrect information.*

There are actually several types of radiation, as I have understood it (neutron radiation). ***Alpha radiation*** *is when an unstable nucleus sends out a helium nucleus (2 protons and 2 neutrons). The alpha particle is positively charged and moves only a few cm in air. It cannot go through lots of skin and paper and is most dangerous when the radiation source is inside the body. The remaining nucleus then has 2 protons and 2 neutrons less.* ***Beta radiation*** *is when an unstable atom nucleus sends out an electron with high speed, by turning one neutron into one proton and one electron. The beta particle therefore has a negative charge. Beta radiation is dangerous if the radiation source is inside the body, because the radiation can only reach a few meters in air and can go through a little bit of skin, paper and clothes. After beta radiation the remaining nucleus has one proton more, but the same atomic number (nucleons=neutrons + protons in the nucleus).* ***Gamma radiation*** *is something that often occurs after alpha-/beta- radiation when protons and neutrons in the nucleus have to find new positions because of the instability there. After alpha-/beta radiation the energy level in the nucleus is much higher than it should be in a basic element, so electromagnetic radiation with a lot of energy is sent out, i.e. gamma radiation. Gamma radiation reaches much longer distances than alpha- and beta-radiation. Even through lead and some metals, but not thick ones. If the radiation source is inside the body the gamma radiation is therefore not dangerous, only if it is on the outside.*	This answer is much more elaborated than most other students in our sample. Information in this answer can be traced back to many animations in the program. *Coded as Using scientific idea*

Examples from delayed posttest

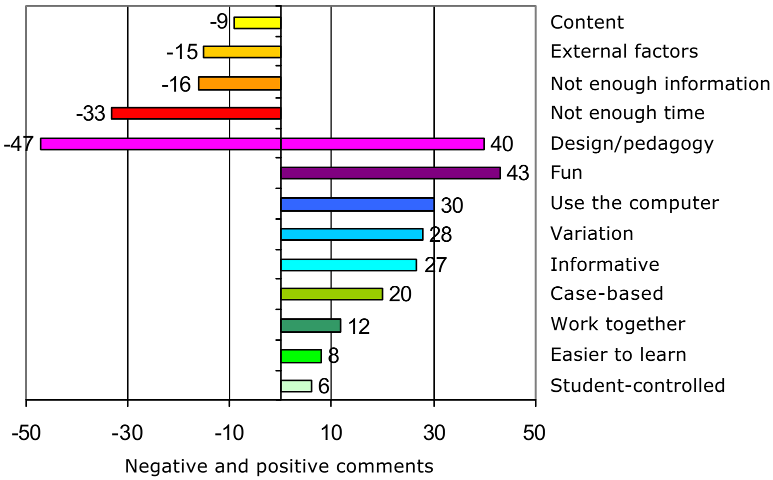
Gamma radiation: something that happens after an atom has sent out a beta or alpha particle. Happens because the atom has excited. Then radiation is sent out. Alpha radiation – when an atom with an unstable nucleus sends out a proton and a neutron=alpha particle. Beta radiation- when an atom with an unstable nucleus sends out an electron. This happens when a neutron turns into an electron and a proton. The atom now has one more electron in the nucleus, but it is the same number of nucleons.	This student gives an elaborated explanation on the three types of radioactivity, even though the description of the alpha particle, and that a neutron remains in the nucleus is wrong. *Coded as Mix of correct and incorrect information.*
Gamma: strongest, most penetrating: skin, bone. Most dangerous from outside the body. Beta: next most strong, a bit penetrating; clothes, most dangerous inside body. Alpha: least dangerous. Penetrating paper, most dangerous from inside the body.	Example of answer that can be traced back to the animation in Figure 5. *Coded as incomplete scientific idea*

To summarize; almost all students knew the names and the charges of the three radiation types, this information seemed to be retained by many also after two months. A large number of students also mentioned the penetrating power of alpha, beta and gamma radiation, some of them made drawings to illustrate their point. All the drawings in students' responses were related to the animation sequence described in Figure 5. Many students connected information about penetrating power to the human body, and whether a radioactive source was most dangerous outside or inside the body. As mentioned above this is the task that facilitated the most elaborated student answers both in posttest and delayed posttest. All the units in *Radioactivity* containing information about the different types of radiation, contained animations and tasks related to these animations.

Student opinions on Radioactivity

To get feedback from individual students on their opinion about *Radioactivity*, students were asked to write four positive and four negative remarks about *Radioactivity* on the posttest. Furthermore, they were also encouraged to submit suggestions for changes. Most students had four positive comments, but many did not have four negative ones; this gave a clear predominance of positive comments. There was also greater variation in the positive comments, as compared to the negative comments. The students' responses are interpreted and categorized as shown in Figure 7.

Figure 7: *Summary of students' negative and positive comments about Radioactivity. The comments are categorised based on statements from 64 students.*



Positive comments

In Figure 7 we observe that 43 comments are classified as fun. This category contains words like exciting, fun, engaging or interesting. 40 comments are positive to the design and pedagogical arrangements of the content, e.g.:

"Simple and easy to use."
"A good thing with a small quiz during the program, so that we can check what we have to practice more on."
"Very good explanations."
"Not too much content at one time, not too monotonous."
"The content was presented in another way and was easy to read, so that most of us understood it well."

A lot of students think it is good to use the computer, that *Radioactivity* is informative and provides variation from ordinary science classes. 20 comments described it as exciting to work with a case and have a mission to fulfil, e.g.:

"A good thing that the content was introduced as a journalist case, then it became more interesting."
"A lot of thinking, that was good because it was fun to find the answer."

Furthermore, six comments emphasised the high degree of student control in the work process as positive. And finally, several students also mention that it is easier to learn the content when it is visualized using animations and pictures, and that working together in pairs is positive. The impression from classroom observations is that many student pairs really discussed the content while working in front of the computer. The teacher of two of the classes in this study shared the following comment in an interview, after finishing the work on *Radioactivity*:

Teacher: ... Another thing that I think was very good, was that it wasn't just the scientific content, but also that they could sit together and discuss. Because it opened up for a lot of good discussions where the students came to common solutions. And that it builds the classroom environment in a way, because relations are created, you know. It wasn't always those who normally stick together that worked together this time. I put together pairs a little bit randomly, or not completely randomly, but not necessarily the constellations that normally sit together either. It seemed like they were working well together with this particular teaching sequence. One of the classes is very special, because the students really are a bunch of individualists. These students really need a lot of practice in this thing about teamwork and group work. In a way this program emphasised common solutions. They discussed and came to common solutions, and I think that was good.

Negative comments

There are 47 negative comments connected to design and pedagogical arrangement. This category contains statements like:

"A bit too much to read."
"Sometimes difficult explanations and definitions."
"We had to go through a lot of tasks before we could write the article."
"Too few multiple choice tasks."
"The program is too short."
"Too few animations."

Some students thought there was too much text to read, but as we can see from the citations above, in reality some of the comments classified as negative are also positive comments on the program. That the program was too short might indicate that the student liked working with it, and the comment about too few animations probably means that the student liked the animations present in the program. As mentioned above the teachers involved in this study only allocated four lessons to *Radioactivity*, thereby more than half of the students did not have time to work through the program properly. 33 students thought it was negative that they did not have enough time to complete the program. 16 students say that on some units in the program there was little information for instance:

"Not information on what really happened."[8]
"We got little information on what radioactive radiation might lead to."
"Little information beforehand."

Some students think the content was difficult and/or boring. The category "external factors" includes comments on trouble with Internet connections, noise in the classroom, preordained pairs, and so on.

To summarise; the comments from the students on what they consider as positive and negative parts of *Radioactivity* are interesting. Several statements show that some students do have a conscious relation to their own learning process, and are able to view their own learning in a meta-perspective, e.g.:

"It was good that we had to write an article, we learn better what we write."
"It is easier to understand difficult things when they are illustrated with figures."
"It was pedagogically well organised."

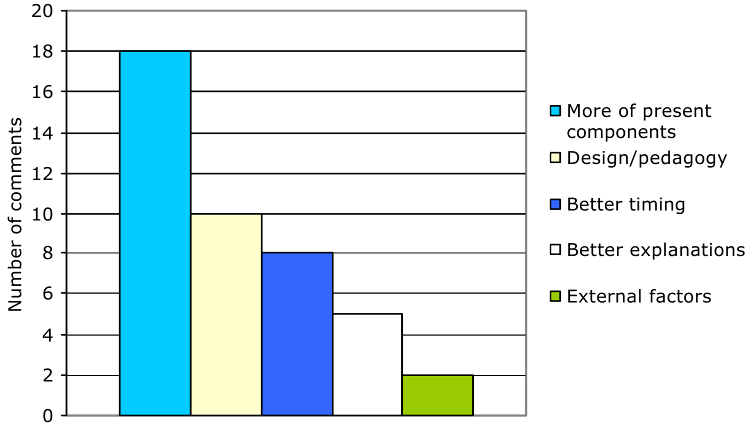
Suggestions for change

We asked the students whether they had suggestions for change in *Radioactivity* (see Figure 8). 18 comments requested more of components already present in *Radioactivity*, like animations, quizzes and laboratory work e.g.:

"More quizzes during the program and more tasks like lab work."
"Use more examples in tasks."
"Use sound."

[8] Information on the solution of the problem is only given in the teacher guidelines

Figure 8: Summary of students' suggestions for changes. Comments are categorised based on statements from 32 students.



Others suggested better timing, since many students did not have time to complete *Radioactivity.* In the category of design and pedagogical arrangements, suggestions of the following type are submitted:

"One could for instance show pictures of people/children that have been hurt because of radioactivity."
"Make small bullet points where you sum up the most important items, so that one doesn't have to go through 9999 animations and questions before you learn something."

The last comment about bullet points is rather amusing, and it illustrates that the answers do not come easily for students in this program. It also indicates that, as we hoped, students do revisit some of the units in order to collect the information they need to solve tasks.

Discussion

This article has attempted to explore some of the characteristics of Viten digital learning materials in the context of a classroom study of the most widely used Viten program *Radioactivity,* including student achievement and opinions of the program.

Features of *Radioactivity*

Real-world context

Radioactivity is set in a practical real-world context where the radioactive sources involved have their origin in smoke alarms and radioactive waste from the Chernobyl accident. *Radioactivity* is built up as a case, where students act as journalists with a mission to accomplish. The designers of *Radioactivity* have developed a convincing setting; with 12 visual units containing information that makes the case credible. The setting was much appreciated by the students, who thought it was interesting and exciting, and it was emphasized by the students that *Radioactivity* offers a welcomed variation to traditional science lessons. This also resonates the view of teachers using *Radioactivity* in their science classes (Mork, in prep.). Roschelle et al. (2000) put forward connections to real-world contexts, as one of four key characteristics of successful teaching resources. Other researchers (e.g. Linn, Davis, & Bell, 2004; Webb, 2005) also emphasise the importance of a context which is personally relevant to students, when designing ICT learning environments.

Content

The goals of *Radioactivity* are identical to those of the Norwegian national curriculum, and teachers using Viten programs emphasise that this is an important factor to consider when choosing to use a program (Mork & Jorde, 2005; Mork, in prep.). Eijkelhof (1996) argues for shifting the focus of teaching about radioactivity from "understanding nuclear physics" towards "being able to understand risk information". In the trade off between elaboration of content and the length of the program, the designers of *Radioactivity* have chosen to elaborate more on radioactivity as a phenomenon, at the expense of radioactivity as a resource and as a threat. This choice is understandable by the very fact that radioactivity is an ”invisible” phenomenon that can be visualised through animations and simulations. The present focus has much in common with how radioactivity traditionally has been taught, both in Norway and other countries (Millar et al., 1990; Eijkelhof, 1996). Hence, familiarity with content might be one reason that many science teachers choose to use *Radioactivity* in their classrooms.

Components in Radioactivity

Radioactivity has many components, ranging from interactive animations and simulations to multiple choice tests and to cell phone text messages popping up during the program. When asked to mention positive and negative features of *Radioactivity*, many students put forward examples like animations and quizzes as positive features, making it easier to understand the content and more motivating to work on. Several authors have developed guidelines for design, content and use of animations in digital learning materials (Rieber, 1990; Milheim, 1993; Mayer & Moreno, 2002). It is interesting to notice a high degree of similarity between such guidelines and animations found in *Radioactivity.* Milheim (1993) for instance, suggests that one should develop simple animations where it is easy to perceive important information, and that animations should include options for varying the speed. Most animations found in *Radioactivity* are interactive, and are kept simple without confusing details and additional effects moreover; the users are in control of the speed. Milheim further argues that animations should be directly related to important objectives in an instructional lesson, especially when the instruction includes an ”invisible” phenomenon as in *Radioactivity.* Overuse of animations should be avoided, but since some students think there are too few animations in *Radioactivity,* overuse is probably not a problem in this case. As shown in Figure 3 and 5, only the content to be explained is in focus on the screen, and supplemented by a relatively small amount of text close to the animation, which is in line with Mayer and Moreno’s (2002) principle that text should be placed close to the corresponding animation. Some of the features mentioned above may seem obvious, but a quick search for animations in educational settings on the Internet will show that this is not the case.

One of the intentions behind Viten programs is to serve as a supplement to other science teaching approaches, providing a wide variety of tasks and activities on traditional science themes or socioscientific issues. In *Radioactivity*, teachers can choose to let students solve the actual case, and they are free to use the whole, or parts of the program in whatever way they want. Just as with textbooks and other teaching resources, there are numerous ways of implementing digital learning materials in schools. Even though *Radioactivity* is designed as a case where students should solve a mission, and is organized according to a menu, only the teacher’s imagination limits how students approach the learning materials. Squire et al. (2003) argue that since all classrooms are unique, it is ultimately the responsibility of the teacher to adapt curriculum materials to fit their own strengths, needs and goals, and also the goals of their students.

Student achievements and opinions about Radioactivity

Student achievement was mapped through pretest, posttest and delayed posttest, and as expected, learning gains were obtained from pretest to posttest; some of which were also retained after two months. The pretest was preceded by a one-hour lecture, which might have influenced student achievements on the test. It must also be noted that for various reasons the teachers only allocated four lessons to work on *Radioactivity,* as opposed to the fact that normally Norwegian 10th graders study radioactivity and radiation for approximately 12 lessons, which is also suggested in the pilot resources for 21st Century Science (Holman et al., 2004). However, due to the limited time allocated, all students did not complete the program, especially not the closing activity; writing the newspaper article summarizing their findings and solution to the case. This activity is time consuming (data from the Viten server), since students continually revisit units in the program (own observation): reading texts and running animations again during the work. A closing activity, where students use and rearrange information in their own language in a new setting would probably have considerable influence on their learning process. Hence, spending more time could potentially have influenced student learning outcomes. The fact that more than half of the students in this study thought that it was negative that they were not able to complete the work, is an indicator of motivation. Students were generally positive to *Radioactivity,* and the categories identified when summarising students positive comments provide some general signals about what students appreciate in a teaching sequence: using computers, variation, informative materials, working together, student control. These are key words to have in mind when planning any teaching sequence or developing new learning materials. Furthermore many students enjoyed the design and pedagogical arrangements in *Radioactivity*,

Looking more carefully at student answers on performance tests revealed that responses to the question "*What is radioactivity?*" seemed to shift from a focus on radioactivity as something dangerous, like atomic bombs and accidents in nuclear power plants, towards a more factual and scientific description of the phenomena. Even after two months 19 % of the students were able to draw on scientific ideas on radioactivity.

The task *"Explain the differences between the three types of radioactivity"* produced the most elaborate answers on the tests. 44 % were drawing on scientific ideas at the posttest, and two months later, 15% of the students still retained this level of explanation. A lot of students connected information about penetrating power to the human body, especially to whether the source was outside or inside the body. In student responses to this task, there were clear indications that they were drawing on the interactive animations presented in Figure 3 and 5, and other animations. For instance, several students made drawings related to the animations described in Figure 3.

Conclusions and Implications

This study describes an innovative approach to teaching about radioactivity, where ICT is used to place students in a context where they have a mission to solve. In this context and through a design that seems to be appealing to students, they become motivated to learn about radioactivity. The fact that almost half the students thought they had too little time, and were disappointed at not being able to continue working on the topic of radioactivity, is something that teachers probably have not experienced very often.

As revealed in this study, the strength of *Radioactivity* is the part focusing on radioactivity as a phenomenon, and the way this is presented. In the program, interactive animations and other remedies contribute to student learning by making the "invisible" visible. Features of the animations are reflected in many student answers. Students are generally very positive to *Radioactivity*. Students involved in this study seem engaged and motivated for learning about radioactivity. Motivation might influence the learning outcome, as discussed in detail by Schofield (1995).

Radioactivity also has its weaknesses, in terms of a less elaborate focus on radioactivity as a resource and as a threat. Good teachers will compensate for these limitations by drawing on other learning materials in addition to *Radioactivity*. When teachers are more familiar with digital learning materials like Viten, we shall probably observe a more creative use of such resources, for instance combining the digital teaching resources with experiments, excursions, and other offline activities in the classroom. The wide range of activities and tasks included in *Radioactivity* might be a reason why the program is easy to adapt locally.

An interesting line of research will be to investigate how individual teachers implement learning materials like *Radioactivity* in their science lessons. Squire et al. (2003) point out that the burden lies with the developers of the curriculum, to consciously increase the flexibility of the curriculum in order to encourage ownership and reinvention by its adopters. The Viten project is taking the consequences of this, and is developing Viten programs to meet specifications and standards of e-learning, so that the content is more open to adoptions and flexible reuse. By transforming the Viten Gene-Technology program into inter-operatible learning objects, the content can be used in virtual learning environments (VLE), so that science teachers more easily can adapt the program (remove, add, or change order) or just use individual components in a new context (Strømme & Sørborg, 2005).

The units regarding radioactivity as a phenomenon have shown themselves to be well designed, interactive and followed up by written tasks. The features of the animations on these units are in line with recommendations from the literature about what is regarded as good quality animations with a potential to promote learning. Results of achievement tests show that students have worked actively on content from these units, and also, after two months, retain information introduced in the program. However, there is room for improvement, regarding radioactivity as a resource and as a threat; something the designers may want to consider in future versions of the program. I suggest that it would strengthen the program if remedies from the animations, interactive- and written tasks regarding radioactivity as a phenomenon were used to elaborate more on radioactivity as a resource and as a threat: e.g. interactive units on how ionizing radiation is used for medical purposes like X-rays and cancer treatment. Likewise, there could have been more focus on radon, the single source providing the largest radiation dose to most Norwegians, and an issue that World Health Organisation is most concerned about. More elaboration on how nuclear power plants work, and how radioactive waste from these is handled would also improve the program. One of the major advantages about ICT and digital learning materials is that the materials can easily be changed to better fit their purpose.

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Appendix 1

Overview of questions in achievement tests, categorised according to the objectives in the national curriculum (A-C).

A) Radioactivity and the characteristics of the three types of radiation.

Multiple choice questions

A.1 What is Becquerel?
- A radioactive substance
- A unit of measurement for radiation activity
- A unit of measurement for radiation dose

A.2 Which of these claims are right?
- A radioactive atom has an unstable nucleus
- A radioactive atom has no nucleus
- A radioactive atom has a stable nucleus

A.3 Where does most of the background radiation come from?
- The ground and radioactive substances in the earth's crust
- Radioactive vast
- Areas around nuclear power plants
-

A.4 What does a beta particle consist of?
- An electron
- A neutron
- Two protons and two neutrons

A.5 What is the electrical load of gamma particles?
- No load
- Negative load
- Positive load

Open ended questions

A.6 What is radioactivity?

A.7 What are the names of the three types of radiation? (pretest)/ Explain the difference between the three types of radiation (posttests).

A.8 List the name of some radioactive materials. When and where did you learn about these?

A.9 What does a Geiger counter do?

B) Ionising radiation as a resource for the modern society.

Multiple choice questions

B.1 Which of the following apparatus contain a radioactive substance?
- Computer screen
- Smoke detectors
- Outdoor thermometers

Open ended questions

B.2 Can radiation be useful? If so, how can it be used?

C) Ionising radiation as a threat to the natural environment.

Multiple choice questions

C.1 Which consequences can resilience of radioactive vast have for the environment?
- No consequences
- It can be incorporated in the food chains and amongst other things lead to cancer and damage on DNA
- It can lead to flourishing of poisoned algae along the coast

Open ended questions

C.2 In 1986 there was an accident at a nuclear power plant in the city of Chernobyl in Ukraina. What do you know about this accident?

C.3 Which radioactive isotopes where spread from the accident in Chernobyl?

C.4 What happens to people who are exposed to radiation for a long period of time?

Appendix 2*:*

Coding scheme for nine open ended questions identical in all three tests.

	Question	Code 1	Code 2	Code 3
1	What is radioactivity?	Gives a vague description of radioactivity, or defines radiation in general as transport of energy from an energy source.	Connects radioactivity to something happening in the nucleus, but gives an imprecise description. Does not mention the nucleus, but the three types; alpha, beta and gamma.	Radioactivity is due to unstable nucleuses, trying to achieve a more stable condition. (Three types; alpha, beta and gamma. We are constantly exposed to radiation from the ground, buildings, space and so on).
2	What are the names of the three types of radiation? (pretest)/ Explain the difference between the three types of radiation (posttests).*	Mentions only one type of radioactivity.	Mentions two types of radioactivity.	Mentions all three types of radioactivity, alpha, beta and gamma radiation.
3	Can radioactivity be useful? If so, how can it be used?	Answers yes, but have no examples.	Gives only one-two examples.	Gives at least three examples.
4	List the name of some radioactive materials. When and where did you learn about these?	Mentions only one example.	Gives two-three examples.	Gives at least four examples.
5	In 1986 there was an accident at a nuclear power plant in the city of Chernobyl in Ukraina. What do you know about this accident?	Knows little about what happened, but gives a vague description.	Knows a something about what happened and the consequences of it.	Gives a good explanation of what happened and the consequences of the accident.
6	Which radioactive isotopes where spread from the accident in Chernobyl?	Mentions one isotop.	Mentions two isotopes.	Mentions at least three of the following: caesium, radioactive jod, xenon, barium, strontium.
7	What happens to people who are exposed to radioactivity for a long period of time?	Mentions that they can become sick and eventually die, but do not specify the answer.	Mentions that amongst other things the risk of getting cancer is increasing.	Cells die, organs get damages, mutations, cancer, genetical damages.
8	What does a Geiger counter do?	Have a vague description of what a Geiger counter does, e.g. that it measures radioactivity, but does not mention radiation dose.	Describes that the Geiger counter measures radiation activity, but does not mention that it cannot separate different types of radioactivity.	Register radiation activity from alpha, beta and gamma sources, but cannot differ between them. Unit of measurement is becquerel.

**Question 2 is a bit different in the posttests, so to compare the answers with the pretest, only the names of the three radioactivity types are evaluated in this coding scheme.*

Paper III

Mork, S. M.: A dual approach to analysing student argumentation in classroom debates.
In review for Science Education

A dual approach to analysing student argumentation in classroom debates

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Abstract

This paper presents a novel methodological approach for analysing argumentation in classroom debates. The 'dual approach' takes account of both content and structure of students' argumentation. This approach is explained, and then applied to empirical data from a case study of role-play debates. The role-plays were simulating TV debates between politicians where a general issue, including several sub-issues would be on the agenda. A web-based teaching program[1] served as the information source for the debates. Three role-plays about the controversial issue of the introduction and protection of wolves in Norway were conducted by a class of students age 14-15. Analyses of the transcripts show that students use biological, personal/social, political and economic arguments in the debates, and that the content in the majority of student utterances is of the expected quality. Moreover, student utterances vary from containing just simple claims, to more elaborated reasoning with examples backed up by evidence. The paper concludes with a discussion of the relative merits of the 'dual approach' as a method of analysing student argumentation in classroom debates.

Introduction

The purpose of this paper is twofold. First, I develop a methodological approach for analysing student argumentation in terms of both structure and content of argument. Second, I apply this method to assess student argumentation in science role-play debates.

Argumentation is particularly relevant in science education since there is now a well-attested body of empirical evidence that science emerges not as coherent, objective and unproblematic knowledge, but as uncertain, contentious and often unable to provide answers to the many important questions with the required degree of confidence (Jenkins, 2002). Hence, a goal of scientific inquiry is the generation and justification of knowledge claims, beliefs, and actions taken to understand nature (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000). These features of the nature of science should be reflected in science education, and science educators seems to agree that science teaching needs to go beyond teaching about "what we know" and establishing familiarity with the basic techniques of the domain. Equally important is the need to teach about "how we know", by focusing on how evidence is used in science for the construction of explanations, and focusing on the criteria used to evaluate the selection of evidence and construction of explanations (e.g. Driver, Leach, Millar, & Scott, 1996; Duschl & Osborne, 2002; Jimenez-Aleixandre et al., 2000). According to Millar and Osborne (1998), there is a growing body of evidence that engaging in argumentation generates the kind of knowledge and understanding essential to scientific literacy; and there is some evidence that argumentation improves student engagement and interest in science. Socioscientific issues, i.e. issues that encompass social dilemmas with conceptual or technological links to science (Sadler, 2004), are often used as means for students to practice argumentation skills (e.g. Jimenez-Aleixandre et al., 2000; Sadler, 2004; Zohar & Nemet, 2002).

In this section, a flavour of some of the theoretical perspectives that have been drawn upon regarding debates and argumentation in science lessons will be given, with a view of informing the subsequent development of an alternative way of analysing students' argumentation. The newly constructed dual approach is applied on empirical data from biology role-play debates, to answer the following research questions:

- *What is the structure of students' argumentation?*
- *What is the content of students' argumentation?*
- *How does structure relate to content in students' argumentation?*

Theoretical background

Developing skills in argumentation is not only a goal for science education, but also a general educational goal. Deanna Kuhn (1991), suggests that argumentation skills do exist among people, but these skills are not always fully developed even amongst adults, a contention supported by findings of Zohar and Nemet (2002); hence Kuhn argues that the educational challenge lies in reinforcing and strengthening skills already present in at least implicit forms. Consequently, if young people are to reinforce such skills, science teachers need to offer students opportunities to talk and practice how to articulate reasons for supporting a particular claim; how to attempt to persuade or convince their peers; how to refute the arguments of others; how to ask questions; to relate alternate views etc (Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002; Newton, Driver, & Osborne, 1999).

Toulmin (1958) defines argument as an assertion and its accompanying justifications, whereas Costello and Mitchell (1995) suggest that argument can be understood as a means to put forward a position in preference to others, and as a means to discover a perhaps shared perspective: i.e. argument to win, and argument to arrive at a decision. They further state that argument can be understood in terms of competition and consensus, where competition refers to the role of argument in setting a position or person apart; and consensus, the role it plays in bringing positions together.

So far, a main focus of research on argumentation and controversial issues in science education has been on the process of argument rather than its content, e.g. evaluation of the students skills in constructing arguments and how students form opinions concerning controversial issues (e.g. Erduran, Simon, & Osborne, 2004; Jimenez-Aleixandre & Pereiro Muñoz, 2002; Kuhn, 1991; Osborne, Erduran, & Simon, 2004; Simonneaux, 2001). Toulmin (1958) described a universal structure for arguments that articulate how claims are made about data, and the legitimacy of any particular claim about data rest on the warrants offered in its support. Toulmin's argument pattern has been widely used to generate categorizations to assess the structure of arguments in classroom debates, also in science education. In a study of 9th grade students capacity to develop and assess arguments regarding genetics, Jimenez-Aleixandre et al. (2000) apply Toulmin's argument pattern to assess the structure of arguments. They augment Toulmin's framework with what they call epistemic operations, but remain the focus on the form of student arguments. The argumentation patterns reported from this study varies from sophisticated arguments to isolated claims, and students are very limited in terms of epistemic operations, where most arguments focuses on causality and appeals to analogies (ibid). Erduran et al. (2004) extend the applicability of Toulmin's argument pattern through the use of two methodological approaches for tracing argumentative discourse in science classrooms: in Method 1, they trace the distribution of Toulmin's argument pattern in whole-class discussions and develop profiles for the lessons of the involved teachers. They are then able to compare the argument patterns in different classrooms, and between the two years the study was conducted. Significant differences are reported between years in terms of more elaborated argumentation being used the second year. In Method 2, Erduran et al. perceive the presence or absence of a rebuttal as a significant indicator of quality of argumentation. A framework on quality in terms of five levels of argumentation is developed, where level 1 consists of arguments that are simple claims versus counterclaims, and level 5 displays an extended argument with more than one rebuttal. Results from this interesting study indicate a positive development in the quality of argument. Patronis, Potari, and Spiliotopoulou, (1999) assess the process and nature of student argumentation drawing on parts of Toulmin's argument pattern. The process refers to the ways in which students express their arguments, and the nature of arguments distinguishes between qualitative arguments; based on social, ecological, economic or practical aspects of the situation discussed, and quantitative arguments including numbers and calculations of formulas associated with school science. This study has an interesting approach, where the authors suggest that students did formulate reasonable supporting and refuting arguments. However, I agree with Sadler (2004), that Patronis et al. do not provide sufficient documentation to support their conclusion.

Toulmin's argument pattern has been useful for describing the structure of arguments. Toulmin (1958) pointed out that although the structure of arguments may be the same across disciplines, the quality of arguments depends on standards developed within disciplines. Several scholars have reported limitations in using Toulmin's framework to assess the quality of argumentation for instance: Toulmin's approach does not lead to judgements about the correctness of arguments (Driver et al., 2000), the distinction between the Toulmin components, in particular whether an item is data, a warrant or a backing, may be difficult to handle (Duschl & Osborne, 2002), and the framework is restricted to relatively short argument structures (Kelly & Takao, 2002).

Sandoval and Millwood (2005) recognise that structural analyses of students' arguments are important to understand how they appropriate desired practices of argumentation, but they further argue that these analysis should include judgements of the quality of arguments that fit some target structure. One main reason for engaging science students in argumentation is its potential to generate knowledge and understanding essential to scientific literacy. Above I have picked three examples among many studies of argumentation. They all have interesting features, but what do they tell us about students learning of science? Is it so, that if an argument is sophisticated in terms of including warrants, backings and rebuttals, it also includes correct subject content? Or could it be that sophisticated arguments could contain trivialities or misunderstandings of scientific content?

Another approach to categorizing classroom discourse is that of Neil Mercer and colleagues (e.g. Dawes, 2004; e.g. Mercer, 1995; Mercer & Wegerif, 1999). By studying small group discussions, Mercer (1995) developed three ways of characterizing discourse: as disputational, cumulative and exploratory talk, where the last is considered the most complex:

- ***Disputational talk,*** *where characteristic discourse features are short exchanges consisting of claims and challenges or counterclaims. The relationship is competitive, differences of opinion are stressed rather than resolved, and the general orientation is defensive.*

- ***Cumulative talk****, where characteristic features are repetitions, confirmations and elaborations. Ideas and information are certainly shared, and joint decisions may be reached; but there is little in the way of challenge, or constructive conflict, in the process of constructing knowledge.*

- ***Exploratory talk****, during which speakers engage in critical but constructive discussion about each other's ideas; when challenges are made, they are backed up with argumentations and alternative viewpoints are suggested. Compared with the two other types, knowledge is made more publicly accountable, and reasoning is more visible in the talk*

Driver et al. (2000), argue that Toulmin's argument pattern presents argumentation in a de-contextualized way, where no recognition is given to the interactional aspects of argument as a speech event, nor that it is a discourse phenomenon that is influenced by the linguistic and situational contexts in which the specific argument is embedded. In contrast, Mercer's approach sees each utterance in connection with other utterances and thereby takes into account the fact that each utterance is a part of a wider context. In the context of this study, an utterance is defined as all that is said by one person before another person continues the line of discourse. In this perspective on language, an utterance not only reflects the voice producing it, but also the voices to which it is addressed; and according to Bakhtin (Wertsch, 1991), *"Every utterance must be regarded primarily as a* ***response*** *to preceding utterances of the given sphere".* Hence any utterance is a link in the chain of speech communication. The addressee's voice is also involved in the chain of speech communication, in as much as the speaking voice may indicate an awareness of it, and reflect it in the very production of utterances (ibid).

Few scholars have explored the quality of student argumentation in terms of both structure and subject content, for instance: Zohar and Nemet (2002) investigate the quality of 9^{th} grade students' argumentation on genetics according to number and structure of justifications, and the extent of which students are able to consider biological knowledge. Results show that following instruction, the frequency of students who referred to correct, specific biological knowledge in constructing arguments increased from 16.2% to 53.2%, and students in the experiment group scored significantly higher than students in the comparison group regarding genetics knowledge. Zohar and Nemet conclude that integrating explicit teaching of argumentation into the teaching of dilemmas in human genetics enhances performance in both biological knowledge and argumentation. In a recent study, Sandoval and Millwood (2005) analyse high school students argumentation in written explanations of two problems on natural selection. Software tools on evolution, specially designed to support students' inquiry into natural selection are used. Sandoval and Millwood conduct three types of analyses; *Conceptual quality*, showing that students are very good at articulating explanations in terms of natural selection, *Sufficiency of data*, which is judged in terms of whether or not students cite enough of the relevant data to justify their claims. The results suggest that when students are able to make warranted claims, they tend to cite the evidence sufficient to support those claims. Conversely, when the data are not well understood, it is hard to cite sufficient evidence. As a complement to the content-based schemes of conceptual quality and sufficiency, Sandoval and Millwood use the notion of *Rhetorical reference* as a structural component of argumentation. Five types of rhetorical references are identified: inclusion, pointer, descriptions, assertion and interpretation, where simple inclusions are reported as the most common type used by the students.

The studies of Zohar and Nemet (2002) and Sandoval and Millwood (2005) represent the emergence of a new trend for analysing student argumentation that also takes subject content into account, in contrast to other studies of argumentation in science education, focusing mainly on structure and form. One does not yet know whether these methods are applicable in other contexts than the ones reported. However, content analyses that can capture the content quality of students' explanations together with their argument structure, are crucial to be able to assess whether or not students really get better at constructing good explanations (Sandoval & Millwood, 2005). The present study aims to continuing this important line of research, in establishing a set of methods to analyse both the content and the structure of student's arguments. In this paper, Mercer's approach is used for analysing the structure of student arguments. However, due to the nature of the empirical data analysed in this study, it was necessary to expand on Mercer's framework. The content of student argumentation is analysed according to the degree of correctness, and classified according to four conceptual categories.

Design and methodology

An important element for engaging students in argumentation processes in classrooms is establishing effective contexts and conditions for such discourse to take place. Such contexts can for instance include considerations of socio-scientific issues involving the application of science, problem-based learning situations, or computer mediated situations (e.g. Duschl & Osborne, 2002). The empirical part of the research reported here is from a context of role-play debates preceded by work in a web-based learning environment. The issue on the agenda is the question about the continued presence of wolves in the Norwegian landscape, which is highly controversial in the Norwegian context. The wolf was almost extinct in Norway 30 years ago, and is now making a slow reappearance with about 20-30 individuals in 2005. The Norwegian people do not agree on the issues surrounding the presence of wolves in the landscape. The Norwegian government is obliged to protect endangered species such as wolves according to the Bern convention; a view shared by environmentalists and many others in the general public. On the other side of this conflict are sheep farmers practicing free-range farming and their sympathisers as well as those afraid of wolves, seeing the introduction of wolves as a threat to their economic and personal well being. The wolf controversy fits in well with biology teaching, since much of the debate is related to biology, and to ecological management questions like: *"How does the wolf population influence other species?",* where answers draw upon e.g. the concepts of population dynamics, predator-prey relations, and various initiatives to avoid encounters between wolves and livestock (Mork, 2005). The web-based teaching program: *Wolves in Norway,* developed by the Viten project (For a more detailed description see Mork & Jorde, 2004) was used in this study. *Wolves in Norway* consists of online activities like: evidence pages, quizzes, animations, graphics, reflection notes, drag and drop tools etc, developed to scaffold students in the process of gaining various types of information on the wolf conflict. The work with *Wolves in Norway* was followed by off-line role-play debates. The aims of the teaching sequence were that students should: *1) learn about fundamental ecological ideas like population dynamics and predator-prey relations* and *2) practice argumentation skills through the use of information gained in Wolves in Norway.* Argumentation is implemented directly in *Wolves in Norway*, where two newspaper articles with interviews of people representing both sides of the conflict are introduced. The articles are followed by tasks where students are asked to identify the arguments that each person uses to promote their view. *Wolves in Norway* ends with a task where students should construct a list of arguments for and against wolves. However, the class involved in this study ended the teaching sequence with role-play debates about the wolf controversy.

Sample

Participants in this case study were a class of 23 Norwegian students age 14-15. The teacher was the author of this paper, at that time working as a lower secondary school science teacher, and not knowing at the time that I would later approach the data as a researcher. The teaching sequence on wolves lasted over a period of two weeks. All students worked in pairs, using four lessons to work through the web-based activities and two lessons preparing and performing the off-line role-play debates (Mork, 2005). The debates were video recorded and transcribed.

Debate context

The closing activity in *Wolves in Norway* is a crucial part of the teaching sequence, where students have the opportunity to apply information collected and processed throughout the time they have worked on a topic. In the setting of role-play debates, students used the available information to make, support and justify their arguments and claims regarding the question of continued presence of wolves in the Norwegian landscape. Role-play and debate are recognized as useful strategies when teaching about socio-scientific issues (Ratcliffe & Grace, 2003). Students were randomly assigned roles as representatives for nature protection organisations (N) to argue for wolves, or farmers or hunters organisations (F) to argue against wolves. Furthermore, they were encouraged to identify information from the wolf program and other web links which supported their given point of view, and defend this view in a debate context. By taking part in such debates, students could get a better understanding about the complexity of socio-scientific issues involving biological, cultural, political, economic and ethical aspects.

As mentioned above, the role-plays were simulating TV debates between politicians, where a general issue including several sub-issues would be on the agenda, a context familiar to most students. The reason for choosing this design was that the medium of TV debates and role-plays are good ways of focusing on the nature of the discourse, promoting an argumentative mode of discourse where students construct and defend arguments and refute the arguments of others, independently of their own opinion about the issue (Mork, 2005). In an empirical study, Kolstø (2000) observed that role-playing increased the possibility for understanding the viewpoints of others when placed in their situation. Ødegaard (2001; 2003) suggests that the use of drama in science education is valuable to create specific contextualized learning environments, where not only scientific issues are in focus, but where the participants are put in a social and personal context. The present debate setting promoted a disputational frame, in which the relationship between the groups was competitive: differences of opinion were stressed rather than resolved, and the general orientation was defensive.

Three debates were conducted during one class period: each lasting about 10-15 minutes. The debates were organised as a panel with two opposing groups, each consisting of three-four students. As the teacher, I defined the general content frame and, through various interventions when acting as a moderator, had the opportunity to influence and shape the debates according to the aims of the wolf teaching program (Teacher interventions are described in Mork, 2005).

Students that were not in the panel had roles as audience participants, who could ask and challenge those in the panel. Former experiences on non-active audiences showed that students in the audience were eager to participate, and anxious for their turn to sit in the panel. Similar experiences are confirmed by Simmoneaux (2001), who reported that the observers felt frustrated at not being able to take part. By involving the audience, the students were given several chances to participate and become engaged. The total learning experience is one of listening as well as participating.

A dual approach to analyzing argumentation

To investigate students' argumentation, there was a need to find a way of identifying both the structure of arguments and the type of content. Regarding structure, student utterances were analysed according to the features of Mercer's (1995) categories for small group discussion: disputational, cumulative and exploratory talk. When analysing, Mercer and colleagues select sequences of talk from video-recordings of classroom discourse and classify the type of talk dominating the whole sequence. In the present study, as the researcher, I have found it fruitful to analyze all student utterances in the three debates, in total 108. However the first two student utterances in all debates are the initial statements of each group. Most of these include several viewpoints and are therefore treated as more than one utterance, hence a total of 119 utterances are analysed. Each utterance is classified at the individual level; however, it is interpreted as a part of the interaction, i.e. each utterance is seen in connection with other utterances. When analyzing the transcripts according to Mercer's categories, it became apparent that there was a need to include an additional category, since some utterances did not fit the original categories. These utterances share the characteristics of disputational talk, but they are more elaborated in terms of also including reasoning. However, I do not consider these utterances to be as sophisticated as exploratory talk; and hence, another category, *"Reasoned disputational talk"* is added (see Table 1). Table 1 provides an overview of the characteristics of the types of talk, including examples of each type of talk, translated from Norwegian by the author. It must be noted that single examples of type of talk in Table 1 does not include all the features of each type of talk.

Table 1: *Overview of types of talk and the features of each type, based on Mercer (1995). N-students represent nature protection organizations; F-students represent farmer and hunter organizations.*

Types of talk	Features of talk	Examples
Disputational	▪ Claim ▪ Counterclaim ▪ Challenging question ▪ **Avoids answering question***	*Example 1:* ***Student N2:*** *"Actually, as it is nowadays, humans kill more wolves than wolves kill humans."* ***Student F2:*** *"Yes, but it isn't humans that are threatened by wolves. It is...."*
Reasoned disputational*	▪ **Claim with reason*** ▪ **Counterclaim with reason***	*Example 2:* ***Student N4****: "They don't live in captivity, they live on 300 km² "* ***Student F1:*** *"Yes, but they are wandering animals, you said it yourself... They like to wander. It (to be caught) is against their nature."*
Cumulative	▪ Repeat ▪ Confirm ▪ Elaborate	*Example 3:* ***Student N4:*** *"You don't have a relationship to your animals if you release them out in the woods and just let them go there on their own. Either you must look after your livestock, or you must find yourself something else to do!"* ***Teacher:*** *Comment from student N1 (asks for permission to speak)?* ***Student N1:*** *"Yes, when you let your animals out in the nature there will certainly be predators there, and you must take the consequences of that!"* ***Teacher:*** *Student N3 (asks for permission to speak)?* ***Student N3:*** *"Yes, I was going to say the same thing."*
Exploratory	▪ Explain ▪ Reason ▪ Offer alternative solution ▪ Challenge backed up by evidence / reasoning ▪ **Comparison***	*Example 4:* ***Teacher:*** *"Audience?"* ***Student in the audience:*** *"Yes, the so called wolf zones, I think they will fail. Because it is a fact that wolves wander, and then they will wander to the old places wouldn't they? But of course, they have territories, I know that, but then there are these "vagabond" wolves that part from the flock and wander freely. Then it creates a family with another wolf that it meets you know? And then you have another flock. And this is not in the same territory and not in the wolf zone. It can move to another place can't it?"*

**Reasoned disputational talk and features in bold are added by the author.*

The first example in Table 1 is a claim followed by a counterclaim from another student. In Example 2, student N4 has a counterclaim with reason, defending a suggestion about establishing so-called wolf zones where wolves could be protected. Student F1 responds by another counterclaim with reason, where she in a sophisticated way uses a previous utterance by student N4 to argue against him. In Example 3, student N4 presents a claim with reason while student N1 and N3 repeat, confirm, and elaborate on his utterances. The utterance of student N3 demonstrates that classifying the type of talk of some utterances in isolation will not make sense as the utterances build on each other. The talk in Example 4 is classified as exploratory, since it is not only a counterclaim, but also contains an elaborated reasoning with an example and a challenge backed by evidence.

To investigate student argumentation, there is a need to look at the content as well as the structure, owing to the fact that some of the main reasons for using argumentation in science teaching are to improve the understanding of concepts and improve the quality of decision-making on socio-scientific issues. Here student argumentation is analyzed in light of the stimulus of *Wolves in Norway*. The presence of information is evaluated on the basis of what one could expect students to have learnt from working on *Wolves in Norway*. The content of student utterances was therefore categorized according to the extent to which they were able to draw on information from *Wolves in Norway*, or other sources, and use it correctly. The following hierarchy of categories was used: expected-, moderate-, incorrect- and other content. Expected content indicates a certain degree of understanding of aspects in the wolf conflict, whereas moderate content is partly correct and often inaccurate. The last category contains utterances that are difficult to classify according to the first three categories.

Table 2 shows an overview of the tool for analyzing content followed by examples illustrating how the tool is applied in the data analyses.

Table 2: *Categories for classifying quality of content in students' utterances. N-Students represent Nature protection organizations, F-students represent farmer and hunter organizations.*

Types of content	Features of content	Examples	Commentary
Other	-Trivial content -Content on the edges of the original theme -Non-finished sentences -No particular content.	***Example 1*** *"Yes, how long is it since the last time you ate meat, student N1?"*	Illustrates a type of utterance that is classified as out of context, because it is not focused on the original theme.
Incorrect	-Incorrect use of information from the program -Brings in incorrect additional information.	***Example 2*** *"But wolves haven't killed humans."*	Not consistent with the information provided in the wolf program. Wolves actually have killed humans; both in Norway (200 years ago) and other countries; however, it usually happens only under specific circumstances.
Moderate	-Partly correct, but inaccurate use of information from the program. -Brings in partly correct additional information.	***Example 3*** *"Yes, of course, but the fact is that we are getting very small amounts of money from the government... for support. So we cannot afford to do something else. We cannot afford paying wages to shepherds and things like that. So that is the only solution if the animals are going to graze."*	Brings in additional information, which is partly correct, i.e. using shepherds is not the only solution to the problem (alternatives are described in the wolf program); and the government might give additional support if farmers test new methods, like using special Polish shepherd dogs.
Expected	-Correct use of information from the program. -Brings in correct additional information.	***Example 4*** *"In the first place the wolf population is still at a very low level, so I can't see that you could have noticed any reduction in the moose population. The wolf population is too small in Norway."*	Draws on information from the wolf program. Refers to the fact that the Norwegian wolf population, at present about 20-30 individuals, still is far too low to influence the large Norwegian moose population (in contrast; about 38 000 moose are shot by hunters every year).

The content of student argumentation was further investigated by analysing the types of arguments that are used in the debates. Two researchers going through *Wolves in* Norway independently, identified main categories and subcategories of arguments introduced in the program. Afterwards these arguments were compared and a list of main categories was produced as shown in Table 3. Additional arguments introduced in the debates by students, and not found in the program, were added to the list of categories. Furthermore, a final category; *Comments* was included.

Table 3: *Classification scheme for types of arguments in student utterances, and numbers of arguments introduced in Wolves in Norway, and arguments introduced in the debates by students.*

Type of argument	**Characteristics of argument**	**Arguments introduced in *Wolves in Norway* (arguments introduced by students)**
Biological arguments:	Those based on biological knowledge about the behaviour and ecology of wolves and other predators, and their influence on other species.	11 (4)
Economic arguments:	Those involving economic gains or losses due to wolves.	2 (1)
Personal/social arguments:	Those connected to feelings such as fear. Those connected to protection of ones person and livestock. Those giving wolves a non-economical value for people.	5 (4)
Political arguments:	Those connected to laws and international agreements, as well as to consequences of the laws and agreements, i.e. management of wolves.	4 (0)
Comments:	Commenting other arguments, clarifying questions or similar.	

The last stage of the data analysis was the inter-rater reliability test. A fellow researcher classified all student utterances independently according to the categories described in Table 1, 2 and 3. Inter-rater reliability showed an initial agreement on 76%. After discussion between the coders, the agreement increased to 92%.

Results

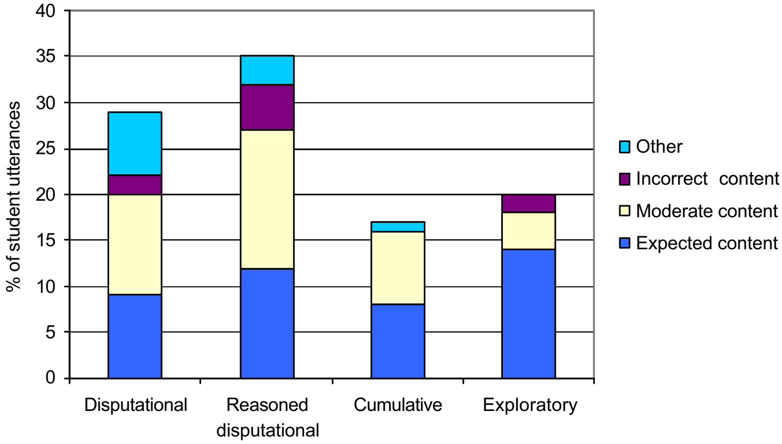
The structure of each student utterance was classified according to the types of talk in Table 1, whereas the content was classified according to the categories in Table 2 and Table 3. The excerpt in Table 4 is an example of how the analysing tools were applied on the empirical data in this study.

Table 4: *Excerpt from one of the role-play debates. N-Students represent nature protection organizations, F-students represent farmer and hunter organizations.*

No	Utterance	Structure	Content	Type of argument
24	***Student F1:*** *Yes, why should we have wolves?*	Disputational (challenging question)	Expected (legitimate question as population has minimal biological influence)	Personal/ social
25	***Student N3:*** *They are a part of Norway then…….*	Disputational (claim)	Moderate (inaccurate)	Biological
26	***Student N:*** *The wolf is an endangered species, and we would like to protect the species we have in Norway.*	Reasoned disputational (claim with reason)	Expected (correct)	Political
27	***Student N2:*** *The wolves are in danger of going extinct, and the sheep are not.*	Cumulative (confirm)	Expected (correct)	Political
28	***Student F1:*** *But, if the wolves are a part of Norway, why are people living in areas with wolves afraid of going out, and letting their children go out?*	Disputational (challenging question)	Expected (correct that some people are afraid)	Personal/ social
29	***Teacher: Yes, have wolves ever killed humans?***			
30	***Student F1:*** *Yes, they have, but of course that's quite a long time ago. BUT, then it is only a question of time before it happens again.*	Disputational (claim)	Moderate (inaccurate, correct that is a long time ago, but we don't know whether it will happen again)	Biological
31	***Student N1****: The wolves are more afraid of humans than we should be of the wolves.*	Disputational (counterclaim)	Moderate (wolves are shy, but we don't know whether wolves are more afraid than humans)	Biological
32	***Teacher: Yes? (to F-group)***			
33	***Student F1****: Wolves have been close to houses and killed dogs tied up outside the house. And then I cannot see that wolves are so afraid of humans.*	Reasoned disputational (claim with reason)	Expected (correct)	Biological
34	***Student N1:*** *But wolves haven't killed humans.*	Disputational (claim)	Incorrect	Biological
35	***Student F1:*** *No, but they are obviously very close (to peoples houses).*	Disputational (counterclaim)	Expected (correct)	Personal/ social
36	***Teacher to N-group: But isn't it so that the wolves are one of the most dangerous animals we have in Norway, with regards to killing people?***			
37	***Student N1:*** *It is more than 200 years since wolves killed a human. If you drive your car into a moose you could die from that too.*	Exploratory (example as comparison to support claim)	Expected (correct)	Biological

Figure 1 visualizes a profile the discourse in the present role-play debates, by showing how the correctness of content in student arguments corresponds to the structure in terms of different types of talk.

Figure 1: *Structure and type of content in student utterances. N=119 student utterances.*

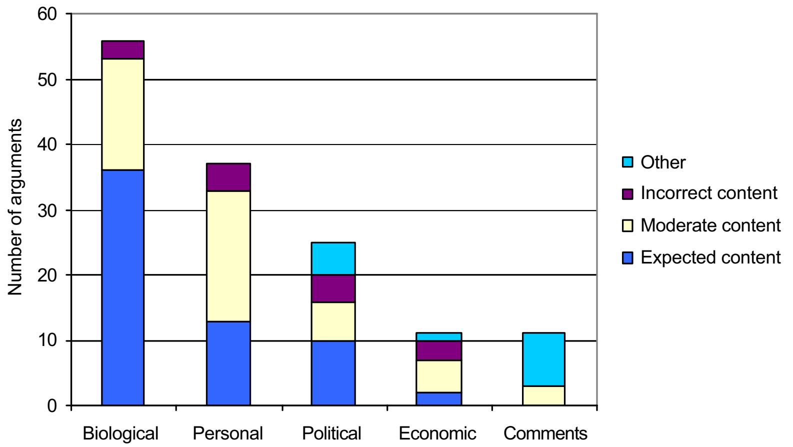


It is interesting to notice that all types of talk are represented in the debates (Figure 1). As one might expect from the chosen debate setting, the dominating types of talk are reasoned disputational (35%) and disputational (29%) however, more than 1/3 of the talk is cumulative (17%) and exploratory (20%)[2].

Regarding correctness of content in student utterances, 43% of the utterances contain expected content, 38% have moderate content while only 9% and 11% of the utterances are classified as incorrect and other, respectively. All content categories are represented in disputational and reasoned disputational talk, while exploratory talk seems to be associated with expected content.

The types of arguments used by the students in the debates were analysed according to the described categories in Table 3. It must be noted that one student utterance may contain several types of arguments hence, 140 arguments were identified in 119 student utterances. Figure 2 illustrates the proportion of the various types of arguments used by the students, combined with the degree of correctness of each type.

Figure 2: *Types of arguments used in the three debates, and the degree of correctness of each type. 140 arguments are included.*



As shown in Figure 2, students most commonly base their arguments on biological information, i.e. the behaviour of wolves, their place in the ecosystem and relation to other species. This could be anticipated since the majority of arguments introduced in *Wolves in Norway* were biological (see Table 3). However, it must be noted that the students brought four additional biological arguments into the debates; for instance that small population size might lead to inbreeding. Furthermore it is encouraging that the students use most of the biological arguments correctly. Personal/ social arguments are also frequently used and nearly half of these arguments where introduced into the debates by the students (see Table 3); for instance that wolves are in conflict with the settlement pattern of people in Norway, and thereby create problems for farmers and hunters. Most of the personal/ social arguments are based on correct or partly correct information. About 25 arguments have political content and mostly concern nature management issues. A few arguments concern the Bern convention; however, it is a bit disappointing that information about laws seems to be neglected, even though they are the foundation for management of wolves. Moreover, only a few arguments are based on economy. Looking more carefully at the distribution of expected content; students are using correct information in all the four types of arguments. However, students seem cleverer at using biological information correctly, as opposed to personal/ social, political and economic information. This might be due to the fact that the majority of arguments introduced in *Wolves in Norway,* and used in the debates, are biological.

Incorrect use of information is evenly distributed among the different types of arguments and do not seem to have any common characteristics.

Discussion

The importance of argumentation in science teaching has been stressed by many scholars, and commenced a growing body of studies focusing on argumentation. However, the majority have concentrated on the structure of argument, at the expense of subject content. This study has aimed at doing both: a dual approach to analyzing arguments is developed, consisting of an extended version of Mercer's (1995) way of categorizing talk in small group discussions, combined with a tool for evaluating the content of arguments.

Structure and content of students' argumentation

Students practiced argumentation skills, when participating in the role-play debates about wolves. Through tasks, students were asked to identify arguments in newspaper articles about the conflict, thus gaining an understanding of the different sides of the conflict. All categories of talk are represented in the debates; however, as one could expect in light of the chosen frame (TV-debates), disputational and reasoned disputational talks are dominating, where argument to win is a likely strategy as opposed to argument to arrive at a decision. The category of *reasoned disputational talk* was added to Mercer's approach, since it seemed to be a gap between the category of exploratory talk and the other types talk. Some of the utterances in the present debates were not just simple claims, but also included reasoning, without being sophisticated enough to be considered as exploratory talk. Reasoned disputational talk is hence a middle category between disputational and exploratory talk, with a potential to provide a more nuanced picture of the discourse in the debates. The high frequency of reasoned disputational talk is encouraging, since the importance of giving reason for claims was emphasized, both in the wolf program and when students prepared for the debate. Without including this category in the analysis, it might have been difficult to notice the fact that the students actually are good at giving reasons for their claims. Bell and Linn (2000) argue that a high frequency of warrants (which is similar/corresponds to giving reasons) in student argumentation is a positive indicator of productive scientific inquiry.

During the debates, students are clever at responding to previous utterances from other students or responding to teacher interventions. The presence of cumulative talk also emphasizes this, indicating that students listen to and build on previous utterances. At some occasions, students also use exploratory talk, which often includes claims with reasons, followed by comparisons and examples to illustrate their point or alternative suggestions. According to Mercer (2000), observational research evidence suggests that very little exploratory talk occurs naturally in classrooms when pupils work together in groups. Most of the talk observed tends to be "disputational" or "cumulative", only involving some of the children, and amounting to no more than a brief and superficial consideration of the topics (ibid). However, these observations are not directly comparable to the present study, as Mercer's group focuses on discourse in small groups in contrast to the whole class role-plays reported here, thus only argumentation in the current study takes place in the context of a debate. Moreover, it must be noted that the respondents in Mercer's studies are primary school students, whereas lower secondary school students are participating in the present study.

The extended version of Mercer's approach to analysing features of classroom discourse is a good alternative to Toulmin's framework. Scholars using Toulmin's framework have faced methodological difficulties like problems distinguishing between data, warrants and backings. Furthermore it has been argued that the Toulmin framework is restricted to relatively short argument structures. Mercer and colleagues have applied their framework on selected sequences of classroom discourse. Similarly, Jimenez-Aleixandre et al. (2000) report that in their analyses they focused only on substantial arguments; the ones in which the knowledge of content is requisite for understanding and involve the use of subject matter. The present study shows that an extended version of Mercer's approach is applicable on the analytical level of individual utterances, and hence; can be used to analyse features of the entire discourse in a debate setting. Due to the nature of this approach, single utterances that may seem difficult to classify, can be analysed in light of previous and proceeding utterances as they, in on the words of Bakhtin; *…"are all links in the chain of speech communication".* Analysing all discourse in a teaching sequence is important, firstly because it gives an overview of students' argumentation skills. Secondly, it gives information on students' ability to express themselves orally at a more general level, which has become one of the profiled goals of the new Norwegian national curriculum, to be implemented in 2006 (UFD, 2005). The analyses in the present study illustrate the flexibility and potential of the extended Mercer approach.

The purpose of this study has not been to rank the quality of various types of talk since the author agrees with Mercer and Wegerif (1999), that any one of the types of talk may be socially appropriate and effective in some specific social context. This argument is vital regarding the context of debates in the present study, where a preponderance of disputational and reasoned disputational talk is identified. These are categories appropriate in the present setting, and the results confirm that expected content is associated with all types of talk. However, viewing Mercer's categories of talk isolated from a context, there is little doubt that exploratory talk is characterized by a more complex structure, compared to the other types. In this light, and in view of Mercer and Wegerif (1999)'s demonstration that exploratory talk is productive talk in terms of constructing the type of knowledge and understanding that is required in schools, it is interesting to note that exploratory talk in the present study is dominated by expected content. Mercer (2000) argues that exploratory talk is an effective way of using language to think collectively, and that the processes of education should ensure that every child is aware of the value of exploratory talk, and be able to use it effectively. In an interesting study, Dawes (2004) provided 5th grade students with "ground rules" for exploratory talk to promote educationally effective talk supporting science learning. She concludes that exploratory talk exchanges generated measurable learning in the science curriculum. There seems to be some evidence that more complex structure of argumentation can be associated with science learning, for instance the study of Zohar and Nemet (2002) demonstrates that after instruction about argumentation, students in the experimental group scored significantly higher than students in the comparison group in test of genetics knowledge. Hence practicing argumentation skills is important and should be a prioritized task in all science classrooms. As suggested by Kuhn (1991) the educational challenge regarding argumentation is to reinforce and strengthen skills that are already present in at least implicit form.

Analysing features of talk is interesting, but it is equally important to find out what students are talking about. From a science educator and curriculum developer's point of view, the subject content of science lessons is important. Combining the expanded version of Mercer's approach with content analyses demonstrate that correct content can be found in all types of talk. The results further show that more than 80% of student utterances include correct or partly correct information from the wolf program or other sources, indicating that students have learnt a lot about the science part of this controversy. Biological arguments are most frequently used but many student utterances also contain personal/ social arguments, especially concerning the threat of wolves to livestock and humans. As reported elsewhere (Mork & Jorde, 2003), both biological and personal/ social arguments are used by students arguing at both sides of the conflict. However, students arguing for wolves use more biological arguments whereas students arguing against wolves use more personal/ social arguments, reflecting the real wolf conflict in the Norwegian context. Likewise, political arguments were most frequently used by those for wolves, while economic arguments were used by those against wolves (ibid).

Factors influencing the outcome of the debates

There is no doubt that many factors influenced the outcome of the debates. Firstly the nature of the present debates was influenced by the TV debate context, which seemed to be a good vehicle for promoting discussion about the present issue. Role-plays in science education are valuable for creating specific contextualised learning environments, that might increase the possibility for understanding others points of view (Kolstø, 2000; Ødegaard, 2003). Student engagement varied: from those who acted as passive observers, to those who played their roles fully and went home before the debate making special hats to emphasize their roles as hunters. Students did not seem to be affected by not being able to choose roles themselves. This can be illustrated by one of the students, who argued passionately for wolves in the first debate and then, because another student was sick, joined another group and argued just as passionately against wolves in the second debate. It was also interesting to note that students who are usually not very interested in science engaged eagerly in both the web-based and debate components of *Wolves in Norway*.

Another major factor that influenced the debate profiles is the nature of the wolf conflict, and the information available in *Wolves in Norway*. Osborne (2004) have suggested that lack of knowledge or conceptions of any relevant theory constrains young people's ability to reason effectively. Hence, having a fruitful debate or discussion on any issue depends on having an adequate information base for students to draw on. The students are influenced by the views of different interest groups presented in the program, including views and arguments they are familiar with from the public debate on wolves. Their argumentation in the debates reflects the choices they have made from the information available to them, but it is also influenced by the roles they are given in the debates.

The third factor that had an impact on the debate outcome is the teacher, who influenced both the structure and the content of the debates, through interventions in the role of being moderator of the debates. Compared to traditional classroom debates, the TV debate setting illustrated in this study, places the teacher in a more limited role as moderator. Being a moderator in a TV-debate implies a more indirect influence in terms of correcting content, but on the other hand it opens up the possibilities to shape the discourse according to the teaching aims. Furthermore it is a natural setting for provoking students and rehearsing argumentative language. As the teacher, I intervened when the content of student utterances was inaccurate, when the debates came to a stop, or went off track. Strategies used were for instance; asking for elaboration, asking challenging questions, rephrasing an utterance and addressing a question to someone else in the panel, interrupting and switching focus etc (For details, see Mork, 2005).

Conclusions and Implications

Based on experiences from the present study, revisions are made to *Wolves in Norway:* more explicit instruction about the structure of arguments is added: firstly, an introductory page to the newspaper articles on opposing views in the conflict is added; where students are asked to read critically, and evaluate the articles according to trustworthiness, i.e. who the interviewed person is, and what could be her/his personal interests in the wolf conflict. Students are further asked to have in mind that a good argument contains claims and reasons supported by evidence, and that persuasive language often is an important means to convince others about a view. Secondly, two more newspaper articles are included in the program. Thirdly, the tasks related to each newspaper article focus more explicitly on how people are arguing for their view in terms of claims, reasons and evidence.

The content analyses of student utterances also lead to some revisions. For instance, few political arguments used in the debates included information about laws and international agreements, which are important factors for the management of wolves. Information about Norwegian laws and international agreements concerning protection of endangered species in the initial version of *Wolves in Norway,* was only available through an anonymous link and may therefore not have seemed important to students. After the revision, these pieces information are introduced directly from the left hand side menu in *Wolves in Norway*, and the following tasks are added: *Wolves are protected by law in Norway however; in some cases they can be shot. Which cases are those? What is the purpose of the Bern convention?* These represent relatively small, but potentially important changes.

Another important implication from this study is the concept of role-play debates, which is now included as a closing activity in the revised version of *Wolves in Norway.* Role-play debates are also further developed and integrated as closing activities in the more recent Viten programs *Bears* and *Gene-Technology.*

The main contribution of this paper is a methodological approach for analyzing student argumentation in terms of both content and structure, as most former studies on student argumentation have focused mainly on structure alone. Adding the new category of *reasoned disputational talk* to Mercer's categorisation system was very helpful for analysing the role-play debates in the present study, showing that students are clever at giving reasons for their claims.

The dual approach to analysing argumentation illustrates the correctness of content in different types of talk. In the present study, both simple claims and more elaborated argumentation did contain correct content. The content analysis of the students' utterances showed that the majority of content in student utterances was correct or partly correct, indicating learning gains. Students used biological, personal/ social, political and economic argumentation reflecting the sense of having access to a tool providing information from multiple sources. Furthermore, exploratory talk seems to be associated with correct content. Maximizing the amount of good quality content should be regarded as a main aim for all classroom discourse. It would therefore be interesting, in a larger scale study, to explore whether there is a connection between exploratory talk and good quality content in general, or whether the context framing the talk might be the most important factor influencing the content.

The present study also demonstrates that the dual approach to analysing argumentation can be used to analyse all discourse in teaching sequences like debates and discussions. In contrast to other approaches where just selected sequences of discourse are analysed, the dual approach provides an important overview of what types of talk that are used in the whole discourse. Furthermore, whether or not the utterances consists of correct subject content, and what type of subject content that is used. Such information is useful for teachers and science educators in evaluating whether students are able to apply subject content knowledge in settings like debate or discussion. In such demanding settings, students have to respond to other utterances immediately. Moreover, the dual approach is a tool that may help teachers considering whether or not they should teach explicitly about the construction of arguments and to which extent the teaching aims regarding subject content are reached.

In the dual approach, curriculum development projects aiming at promoting argumentation and conceptual development through student engagement in socio-scientific controversies now have an instrument to evaluate student argumentation. Identifying and comparing visual debate profiles might serve as important information in further curriculum development. However, more research is needed to investigate the potential of this tool, comparing various types of debates.

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[1] http://viten.no

[2] Due to rounding procedures the sum of % is 101.

Paper IV:

Mork, S. M. (2005). Argumentation in science lessons: Focusing on the teacher role. Published in *Nordic Studies in Science Education*, 1(1), 16-29

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Argumentation in science lessons: Focusing on the teacher's role

Abstract
This paper reports data from a case study of role-play debates on the controversial issue of wolves in Norway. The participants are 23 students at the age of 14-15 and their teacher. Transcripts from the role-play debates are the data sources. The focus of the paper is the teacher role regarding management and teacher interventions in activities involving argumentation. A typology of teacher interventions and reasons for these is developed, that might serve as a useful tool for student teachers and teachers not experienced in managing debates and discussions.

Introduction

Although argumentation is an important activity in science, and an important curriculum goal in science education, activities promoting arguments are not common in science lessons. There are a number of possible reasons for this, although one obvious factor is the role of the teacher. The contributions of this paper is the identification of some potential difficulties regarding management of activities involving argumentation in science, and some of the solutions, through a small scale case study, and hence explore possible reasons why argumentation is not more prominent in science education.

The context of the teaching sequence is role-play debates about the controversial issue of wolves in Norway. A web-based teaching program[1] about wolves developed by the Viten project (Mork & Jorde, 2004) was used, in which students worked on information and various types of tasks ending with a role-play debate. The Viten wolf program is designed to accomplish the following goals: First students should learn about fundamental ecological ideas like population dynamics, predator-prey relations and ecological management. Secondly students should learn about different viewpoints and possible solutions to the conflict. Finally students should practice argumentation i.e. participate in an actual debate where they can draw upon knowledge gained from the Viten wolf program to make, support and justify arguments and claims. The teaching sequence is in line with Sadler's (2004) suggestion that students would benefit, in particular, from instruction related to dealing with contradictory evidence, the formation of counterarguments, and the importance of providing justifications for claims.

[1] http://viten.no

Background

Argumentation is important in science education

Controversy and argumentation are regarded as important aspects of the nature of science (Latour & Woolgar, 1986). Deanna Kuhn (1993) suggests that scientific activity can be characterized in broad terms as exploration and argument, where argument is a supplement to science as exploration. She further argues that not just the theories but even the so-called "facts" of science become argumentative constructions that must be entered into the arena of public debate. The science education community seems to agree that activities involving discourse and argumentation have a potential to enhance learning and hence should have a central place in school science (Driver, Leach, Millar, & Scott, 1996; Duschl & Osborne, 2002; Zohar & Nemet, 2002; Sadler, 2004). This is also reflected in policy documents like *Beyond 2000* (Millar & Osborne, 1998), stating that the reason for situating argumentation as a central element in the learning of sciences has several functions in terms of e.g. generating the kind of knowledge and understanding essential to scientific literacy and improving student engagement and interest in science.

According to Costello and Mitchell (1995) argument can be understood as a means to put forward a position in preference to others and as a means to discover, a perhaps shared, perspective, i.e. argument to win, and argument to arrive at a decision. They further state that argument can be understood in terms of competition and consensus. Argument is a social operation, which is oriented to context and to purpose; it initiates change, it transforms the significance of material, it enables reflection and action, it brings divergent voices together in interaction, it signals belonging within a certain community, it seeks to persuade, to publicize, and to win (ibid).

Research has been conducted regarding argumentation as means of: improving the understanding of concepts, promoting a better grasp of epistemology in science, developing investigative skills and improving the quality of decision-making on socio-scientific issues (Solomon, 1992; Ratcliffe, 1996; Driver, Newton, & Osborne, 2000; Kolstø, 2001; Simonneaux, 2001; Zohar & Nemet, 2002; Mork & Jorde, 2003). However, these studies seem to report on exceptions rather than common practice in science classrooms. As explored below, there seem to be considerable barriers for science teachers to implement such activities in their science classes.

Activities promoting argumentation are not common in science teaching

Solomon (1991) claims that science teaching has failed to empower students with the ability to argue scientifically through the kinds of socio-scientific issues that they are increasingly having to face in their everyday lives. So what do we know about the characteristic features of communication in science lessons today? Mortimer and Scott (2003) have developed a theoretical framework for categorising the communicative approach in classroom discourse. The framework is charactesing the talk between teacher and students along each of two dimensions, *dialogic-authoritative* focusing on the diversity of points of view that are taken into account in the classroom discourse and *interactive-non interactive* focusing on the degree of interaction between classroom participants. Along these dimensions four classes of communicative approach are defined by:

- *Interactive/dialogic:* the teacher and students explore ideas, generating new meanings, posing genuine questions and offering, listening to and working on different points of view.
- *Non-interactive/dialogic:* the teacher considers various points of view, setting out, exploring and working on the different perspectives.
- *Interactive/authoritative:* the teacher leads students through a sequence of questions and answers with the aim of reaching one specific point of view.
- *Non-interactive/authoritative:* the teacher presents one specific point of view.

Each class of communicative approach serves a different educational purpose. However, there is some evidence that most science classrooms seem to be dominated by interactive/authoritative talk: Newton, Driver and Osborne (1999) report that secondary science classrooms are strongly teacher directed and few opportunities are given for students to contribute to the process of constructing knowledge in lessons, and the utilization of small groups, or whole class discussions appears to be very infrequent. An evaluation of the current Norwegian national curriculum for grade 1-10 describes the teaching in all non-practical subjects as generally dominated by teacher control, i.e. instructions and question-answer sequences (Haug, 2003). Similar patterns are found in an evaluation of work forms in upper secondary school physics in Denmark: Teacher lecturing was to a certain extent related to students' active participation in classroom conversations. However, these had features of examinations (Norrild, Angell, Bang, Larsen, Paulsen et al., 2001).

Why are activities involving argumentation not more frequently used?

There could be a number of reasons that science teachers hesitate to engage students in activities that support discourse and argumentation. In a review of informal reasoning regarding socio-scientific issues Sadler (2004) conclude that the promotion of argumentation skills appear to be a difficult educational goal. Driver et al. (2000) have emphasised that science teachers have a limited pedagogical repertoire for dealing with argumentation and classroom discussions. Similarly, James T. Dillon (1994) lists some reasons that discourages teachers from discussions: Discussion skills are difficult and need to be learnt, both by students and the teacher. Discussions are also time-consuming, unpredictable in process and uncertain of outcome as much as unsure of success.

Duschl and Osborne (2002) suggest that before one can expect teachers to engage their students in argumentation, they need guidance in how to approach such issues. Research on teaching strategies for how to deal with activities involving argumentation is therefore needed to meet science teachers' lack of confidence and expertise in this area. Several authors suggest that if young people are to develop the skills of scientific argument, they must be offered opportunities to practice such reasoning, i.e. to articulate reasons for supporting a particular claim; to attempt to persuade or convince their peers; to ask questions; to relate alternate views; and to point out what is not known (e.g. Driver et al., 2000; Sadler, 2004). For such purposes Mortimer and Scott's (2003) notion of interactive/dialogic talk seems to be an appropriate vehicle. This type of communicative approach expects teachers to listen to, and take account of, students' utterances, and giving a type of response that continues the flow of discourse without necessarily evaluating each student's utterance. In contrast to interactive/authoritative talk, the teacher is not having complete control over where the discourse is heading. An interactive/dialogic approach is also in line with Ratcliffe's (1997) suggestion that class discussions are an effective way of encouraging students to explore controversial issues and of avoiding an authoritarian approach. This study reports from classroom debates with an interactive/dialogic communicative approach, focusing on the teacher role regarding management and teacher interventions.

Research questions

- What are the reasons for teacher interventions in managing the debates?
- What types of interventions are used by the teacher to manage the debates?

Design and methodology

Sample

The participants were 23 Norwegian students at the age of 14-15. The teacher is the author of this paper, working as a secondary school science teacher when the teaching took place and not aware of the later approach to the data as a researcher. During a teaching period of two weeks, students spent four lessons working through the online information base and two lessons preparing and performing the offline role-play debates. Debates were video recorded and transcribed.

Role-play debate

The closing activity, where students are able to use information collected and processed through working on an issue, is one of the most important parts of any teaching sequence. One main teaching purpose of the wolf program is to let students participate in an actual debate. The students were expected to identify information which supports a point of view and defend this view in a debate context where the rules were established and explained.

It was decided to conduct the debates as role-plays of TV debates between politicians, i.e. where a general issue and several sub-issues were on the agenda, a context familiar to most students. This design was chosen since the medium of TV debates is a good way of focusing on the nature of discussions and promotes an argumentative mode of discourse where students construct and defend arguments and refute other people's arguments, independent of their own opinion on the issue. Role-playing the various stakeholders in a conflict might help students understand that there is more than one legitimate perspective on a controversy, and that an individual's perspective is influenced by individual interests.

Three debates were conducted during one class period; each lasted about 10-15 minutes and was organised as a panel with two opposing groups, each consisting of 3-4 students. Students were assigned roles for or against wolves and the teacher acted as a moderator while students not in the panel had roles as active audience participants who could ask questions and challenge the panel. Former experiences in a class with non-active audiences showed that in the audience students were eager to participate and almost couldn't wait until it was their turn to sit in the panel. Similar experiences are confirmed by Simmoneaux (2001), who reported that the observers felt frustrated at not being able to take part. By involving the audience students were given several chances to engage.

The teacher's role – a double role

The teacher played a double role in being the moderator of the TV-debate, but she was also still the teacher. She defined the general content frame and through various interventions she had opportunity to influence and shape the debate according to the aims of the curriculum.

The role put some constraints on the teacher e.g. she was not supposed to explain things as in a more traditional teaching sequence. On the other hand the role allowed for strategies like challenging participants in the panel and to keep the debates going by turning statements into questions.

Management and teacher interventions

In managing most classroom situations the teacher must make interventions to maintain the flow of discourse. Here the teacher interventions are related to the curricular goals. In teaching that aims to introduce the students to some of the norms and practicalities of debates, it is important that the teacher models how to behave in a debate setting. Another critical task is to challenge the correctness of information introduced by the students. If this is not done, there is a danger that misunderstandings might be established.

Different kinds of classroom situations result in different kinds of teacher interventions. Several authors suggest that lack of procedures for running classroom discussions might be a main reason why science teachers hesitate to use activities involving argumentation (e.g. Dillon, 1994; Driver et al., 2000). As a response to this line of argument, the present study is developing a typology of teacher interventions and reasons causing them. The purpose of this is to offer teachers a tool that might guide them in developing strategies to handle argumentative discourse.

The data sources in this study are the transcripts of the debates. Data analysis was done through several stages: Firstly all teacher interventions and issues requiring action from the teacher were identified. Secondly these were classified according to the context in which they appeared. From this, the typology of teacher interventions and reasons for these was developed. The last stage of the data analysis was the inter-rater reliability test. The procedures for identifying teacher interventions and reasons were explained to a fellow researcher, who then used the typology as described in Table 1 to independently code all transcripts. Inter-rater reliability showed an initial agreement on 81%. After a discussion between the coders, the agreement increased to 94%.

Results

A typology of teacher interventions and reasons is developed. Six main reasons prompting teacher interventions are identified. These are related to: Accuracy of content, narrow range of topic, debate off track, coming to a stop, level of participation and maintain order of speakers. Each reason prompts some sort of action from the teacher and these actions are characterised as: Challenge the correctness of content, extending the range of topic, get the debate back on track, keep the debate

Table 1: Overview of reasons for teacher interventions, teacher interventions and strategies identified in the debates. The third column shows the curriculum goals related to the teacher interventions.

Reasons for teacher interventions	Teacher interventions and strategies	Curriculum goals
Accuracy of content: ▪ Wrong use of concepts ▪ Wrong combination of information	**Challenge the correctness:** ▪ Rephrase and address question to other group ▪ Ask for elaboration	▪ Learn about fundamental ecological ideas ▪ Learn about different viewpoints and possible solutions of the conflict
Narrow range of topic ▪ Too few sub-topics covered ▪ Incomplete information	**Extending range of topic:** ▪ Pursuing particular parts of students utterances ▪ Ask for elaboration ▪ Reintroducing or introducing sub topics	▪ Learn about fundamental ecological ideas ▪ Learn about different viewpoints and possible solutions of the conflict
Debate off track: ▪ Debate is on the edge of the original theme	**Get debate back on track:** ▪ Interrupt and switch focus	▪ Learn about fundamental ecological ideas ▪ Learn about different viewpoints and possible solutions of the conflict
Coming to a stop: ▪ Authoritative student statement ▪ Student avoids questions ▪ No answer/comment	**Keep the debate alive:** ▪ Rephrase content and turn it into a question ▪ Switch focus, challenge ▪ Ask for elaboration, rephrase question	▪ Practice argumentation skills ▪ Learn about fundamental ecological ideas ▪ Learn about different viewpoints and possible solutions of the conflict
Level of participation: ▪ Too few students are involved	**Involve more students:** ▪ Address question to individual or group	▪ Practice argumentation skills
Maintain order of speakers: ▪ Train students in how to behave in debates	**Focus on debate technique:** ▪ Give students permission to speak on turn	▪ Practice argumentation skills

alive, involve more students and focus on debate technique. Within each action involves one or more strategies that the teacher uses to achieve the same action. It might for instance be that they pursue parts of students' utterances, ask for elaboration or address a question to an individual or group. These interactions are then related to the two broad areas of curriculum goals for the unit as a whole: Learn about subject content and practice argumentation skills. The characteristics of reasons for interventions, teacher interventions and strategies for implementing them are described further in Table 1.

The following section presents examples referring to reasons for interventions, interventions used and the strategies, and also how many occasions these appeared.

1. Accuracy of content

Six instances of teacher interventions related to accuracy of content were identified in the debates, relating to wrong use of concepts and wrong combination of information from different sources. If wrong information remains unchallenged it is likely that students believe this information is correct.

a. Wrong use of concepts

Sometimes the students use concepts wrongly, and the teacher needs to find out whether this is due to a misunderstanding of the concept.

Example 1:

1. ***Student N4[2]*:** "Between 1000 and 500, because we must have about 500 animals to get a viable pack in a way…"
2. ***Teacher:*** "What do you actually mean by viable pack?"
3. ***Student N4:*** "Yes, not pack, but in a way the whole…"
4. ***Teacher:*** "Stock?"
5. ***Student N4:*** "Yes"
6. ***Teacher:*** "What does viable stock mean then?"

Here the student uses the concept "viable pack". To the teacher it is obvious that he means population, since he is talking about that many individuals, but the teacher asks for elaboration (utterance 2) in order to explore whether the student has misunderstood the concept of population, or just forgotten the word. Since the rest of the class is audience it is important to express the right explanation of population. The student responds in utterance 3 but is not confident about the name of the concept and the teacher offers a suggestion before continuing asking for elaboration on viability in utterance 6.

b. Wrong combination of information from different sources

In example 2, the student demonstrates general and correct knowledge about the relationship between predators and prey:

Example 2:

1. ***Student F2[3]*** …"Besides, we in the Norwegian Hunting and Fishing Association have noticed a considerable decrease in the moose population, parallel with the increase in the wolf population. Moose that we could have hunted and sold. Reduction in the moose population means higher prices, and nobody wants that. This is threatening to our business."

[2] N-students represent Nature protection organizations.
[3] F-students represent Farmer and Hunter organizations.

2. ***Teacher:*** "But don't you in the Association for Nature protection have any understanding for these hunters that really have problems? Are there fewer moose to hunt, and do wolves kill their dogs?"
3. ***Student N1:*** "In the first place, the wolf population is still at a very low level, so I can't see that you could have noticed any reduction in the moose population. The wolf population is still too small."

However the student doesn't take into account the wolf population size in Norway: about 20-30 individuals. It is impossible for such a small population to have noticeable impact on the large moose population; by comparison, 38 000 moose are shot by hunters every year. It is therefore important that the teacher challenges this information (utterance 2), and as we see, another student is correcting it in utterance 3.

2. Narrow range of topic

In order to extend the range of the topic according to the curricular goals, the teacher asked questions to pursue particular parts of student utterances, to reintroduce or introduce certain aspects of the controversy. 27 teacher interventions were related to extending the range of the topic.

a. Introduce new information

As part of extending the range of the topic, the teacher on a few occasions introduced a new piece of information to the students:

Example 3:

1. ***Student F2:*** "500-1000, that's an unacceptable number of wolves. We think that we should have as few as possible. And they should be isolated from areas that are needed by people."
2. ***Teacher:*** "How are you going to do that then? Wolves are animals that wander over large areas. How is one supposed to isolate them?"
3. ***Student F1:*** "Place them on an island."
4. ***Student F2:*** "We in the Norwegian Hunter and Fisher Association have worked out a plan for this."
5. ***Teacher:*** "Maybe you could tell us a bit about that plan?"
6. ***Student F3:*** "Yes, we are going to take most of the packs of wolves present in Norway, and place them in one area. A quite large bounded are in a wood in the eastern part of Norway. And there we are going to try to keep them in, in a way. So that in this area we are going to have as few individuals as possible of livestock and other animals the wolves could take. But of course, we must have some moose and sheep and so on, because the wolves have to learn to eat by themselves too.
7. ***Teacher (to N-group):*** "Do you believe that it will be possible to limit the wolves to a restricted area?"
8. ***Student N1:*** "No, absolutely not! The thing is that wolves wander a lot. They are not at rest, and you can't decide that the wolves are going to stay in one area. For example, it is almost the same with bears. They also wander. There was a killer bear here that was moved to Finland, from Norway. But after a year or something, then it was back again, so you can't do that."

In utterance 2, the teacher is introducing the fact that wolves are wandering over large areas, information central to the question of population size and thereby also the controversy. However, this piece of information is not picked up by a student until utterance 8. Utterance 5 is another example related to extending the range of the topic when the teacher asks for elaboration.

b. Pursue particular parts of students' utterances/ ask for elaboration

Students often take for granted that other students have the same knowledge as themselves. A part of the teacher role is to encourage students to share this piece of information with the rest of the class as shown in example 4, where the teacher asks for elaboration:

Example 4:

1. ***Student N4:*** "It is possible to find an arrangement where there are wolf zones that are more limited."
2. ***Teacher:*** "What do you mean by wolf zones? It might be someone that doesn't know."
3. ***Student N4:*** "Wolf zones are zones where wolves live without many people, so that they doesn't create problems."

3. Debate off track

During classroom debates it is not unusual that students get carried away and move away from the original theme. The teacher therefore has an important role in preventing this from happening. This is a challenge because at the same time the teacher doesn't want to intervene too much in the debates. Two teacher interventions were related to debate off track. In example 5, utterance 1 is a typical example of a comment on the edge of the chosen theme. Another student tries to keep to the original theme in utterance 2, but it is difficult. The teacher therefore intervenes by interrupting the discourse and switching the focus to population size by challenging one particular group.

Example 5:

1. ***Student N3:*** "Yes you are saying that the wolves move. Aren't we moving also? We move just as much as the wolves…"
2. ***Student F1:*** "Yes, of course, but there are certain differences between humans and wolves really."
3. ***Teacher:*** "To interrupt you a bit here, how many wolves do you mean that we should have in Norway? How many wolves do you (F-group) mean that we should have? Realistically?"

4. Coming to a stop

There can be a number of reasons that debates come to a stop. I define coming to a stop as incidents occurring when there is a break in the discourse due to authoritative statements from students, students avoiding answering questions or due to no student response to questions or comments. In the present study such incidents occurred eight times.

a. Authoritative statement from a student

Example 6:

1. ***Teacher:*** "But isn't it a pity, because the wolves are important parts of the ecosystem too, aren't they?"
2. ***Student F2:*** "No, absolutely no!."
3. ***Teacher (to N-group):*** "Have you anything to say to that? … Which function do wolves have exactly? Why do you want to protect them?"
4. ***Student F1:*** "Yes, why should we have wolves?"
5. ***Student N3:*** "They are a part of Norway though…"
6. ***Student N1:*** "The wolf is an endangered species, and we would like to protect the species we have in Norway."
7. ***Student N2:*** "The wolves are in danger of going extinct, and the sheep are not."

In utterance 2, a student responds by a very authoritative claim that makes it difficult for other students to continue. The teacher handles the situation by reshaping the question and adds another question addressed to the other group. As we can see, student F1 manages to insert a quick provoking question in utterance 4 before students in the N-group respond to the teacher and continue the flow of discourse in a cumulative manner by repeating, confirming and elaborating (Mork, in prep.).

b. Student avoids question

Example 7:

1. ***Teacher:*** "But you said that the wolves were not dangerous, is that right? Are wolves dangerous? Do they kill humans?"
2. ***Student F2:*** "Humans are not the Norwegian Hunter and Fishing Association's biggest concern…"
3. ***Teacher:*** "But do wolves kill humans? Can we get that sorted out?"
4. ***Student N1:*** "It is more than 200 years since wolves killed a human. If you drive your car into a moose you could die from that too."

Student F2 avoids answering the question from the teacher in utterance 2, and no other students are responding. In utterance 3 the teacher repeats her prior question, but this time in a more challenging way, resulting in a response in utterance 4.

c. No answer or comment from students

Example 8:

1. ***Teacher:*** "Do you have any comments to that (F-group)?"
2. Nobody answers…
3. ***Teacher:*** "But do you (N-group) understand that it is a problem for them that the wolves are eating their livestock? It must be horrible to find their livestock eaten by wolves?"
4. ***Student N3:*** "We do have examples that Polish shepherd dogs have been used to watch sheep."

Here, nobody responds to a question from the teacher, hence she rephrases what has been said earlier and addresses the question to one group in a challenging language to provoke the students. The debate continues with student N3 suggesting an alternative to free range farming.

5. Level of participation

Sometimes just a few students are involved in the discourse. Addressing questions to individuals or groups is an efficient and commonly used strategy to involve more students. Students feel more obliged to answer and participate in such situations. Here, the teacher uses this strategy if one group or the audience has dominated the discourse i.e. had three or more utterances in a row. Five such episodes were identified.

Example 9:

1. ***Teacher (To N-group):*** "Doesn't that sound terrible? It must be terrible to find their livestock that they have a relationship to, killed by wolves?"
2. ***Student N4:*** "You don't have a relationship to your animals if you release them out in the woods and just let them go there on their own. Either you must look after you livestock, or you must find something else to do!"
3. ***Teacher:*** "Comment from student N1."
4. ***Student N1:*** "Yes, when you let your livestock out in the nature there will certainly be predators there, and you must take the consequences of that!"

5. Teacher: "Student N3?"
6. Student N3: "Yes, I was going to say the same thing."
7. Teacher (To F-group): "Yes, what do you say about this?"

Example 9 shows two teacher interventions dealing with the level of participation. In utterance 1 the teacher aims to switch the focus to the N-group after a sequence of four utterances from the F-group. The N-group responds in utterance 2, 4 and 6 before the teacher is involving the F-group again in utterance 7.

6. Maintain order of speakers

36 teacher interventions in the debates were just management i.e. giving students permission to speak on their turn, as a part of learning how to behave in a debate context.

Discussion

The main purpose of this study was to investigate classroom debates and identify some potential difficulties and possible solutions by focusing on the teacher role. A typology of six main reasons for teacher interventions and corresponding interventions is developed. All identified teacher interventions and reasons causing them are of a general character and the typology therefore has a potential to serve as a guiding tool for teachers in managing other debates regardless of issue.

The importance of using activities involving argumentation in science lessons has been emphasized by many scholars (e.g. Millar & Osborne, 1998; Sadler, 2004). However, such activities are still rarely used by science teachers. This is most commonly explained by teachers' lack of strategies for handling classroom discussions and that such activities are both time consuming and unpredictable.

Like many science teachers and students, the participants in this study were not particularly familiar with activities involving argumentation. The teacher therefore took an active role as the manager of the debates. The driving force of her management was the three curriculum goals: Students should learn about some fundamental ecological ideas, different viewpoints in the wolf conflict and they should practice argumentation skills. These goals are in line with Dillon's (1994) suggestion that helping the class to learn how to discuss is a part of helping the class to discuss the topic in question.

There are various interventions teachers can use when dealing with activities involving argumentation. The typology developed here describes six types of teacher interventions: Challenge the correctness of information, extending the range of the topic, get the debate back on track, keep the debate alive, involve more students and focus on debate techniques. Each intervention is made concrete by corresponding strategies like asking for elaboration, rephrasing, address questions to specific students or give students permission to speak. The provided examples show how the teacher through these strategies influenced the content and the flow of discourse in the debates. For instance, students elaborated more on content and focused the discourse according to the original theme.

In classroom debates or discussions the teacher has to act from second to second. With the benefit of hindsight, there are also things that could have been handled differently in the present debates, for instance regarding the notion of wait time (e.g. Wellington & Osborne, 2001). In cases where the debates came to a stop or in situations related to narrowing the range of the topic, the teacher might have waited longer before intervening. Another example is five occasions were the teacher asks two questions almost simultaneously. The second question might include a new concept or information that changes the focus away from the initial one. In doing so, the teacher might confuse the students, or give them a chance to choose which line of information to pursue. If the teacher was conscious about these things before the debate, she could have acted differently in those situations.

The strategies used by the teacher in the presented debates are well known and probably part of most teachers' repertoire of teaching strategies. This suggests that lack of strategies for handling classroom debates (e.g. Dillon, 1994; Driver et al., 2000) need not be a reason why science teachers hesitate to run such activities. For student teachers and teachers inexperienced in handling argumentative discourse, it will be useful to get an idea about situations they might have to respond to in practicing such activities. The typology developed here might help convince teachers that they already possess the strategies necessary for handling debates and discussions. Alternatively, if teachers actually feel unconfident about their own skills, this typology might serve as a guide in developing strategies to handle argumentative discourse. The fact that the typology also provides reasons causing teacher interventions might be very helpful in planning and preparing such activities.

There is some overlap between the strategies used in this study and the six generic strategies for conducting discussions proposed by Kelly (1989):

1. *Asking clear, focused questions*
2. *Waiting for responses*
3. *Calling on non-volunteers as well as volunteers*
4. *Promoting student-student interaction*
5. *Probing for clarity, definition and elaboration*
6. *Checking to see whether one discussant understands another correctly*

Kelly further suggests that these strategies can transform typical classroom discussions from a rapid, ping-pong encounter between the teacher on the one side and a few isolated, highly vocal students on the other to a sustained, thoughtful, and coherent conversation among a broad range of peers. Several studies confirm Kelly's description of typical classroom discussions (e.g. Norrild et al., 2001; Haug, 2003) and the type of communicative approach that can be described as authoritative/dialogic.

The high frequency of authoritative/dialogic discourse reported in many science classrooms might be an obstacle for learning. Mortimer and Scott (2003) see talk as being central to the meaning making process and thus central to learning. They suggest that meaning making can be seen as a fundamentally dialogic process, where different ideas are brought together and worked upon i.e. an interactive/dialogic communicative approach. The discourse in the three present debates can be characterised as an interactive dialogic communication. The teacher and class are discussing and considering different viewpoints of a controversial issue. The students explore information related to the controversy and the teacher helps sustain the discussion both in terms of enabling students to contribute, and in challenging and asking for elaboration on points that are unclear. According to Scott (1998) the nature of teacher utterances in dialogic discourse is: framed to be open to challenge and debate, intended to act as "thinking devices" or "generators of meaning", often based on open or genuine questions where the answer is not obvious, directed towards sustaining dialogue and representing other voices. An interactive/dialogic communicative approach seems to be meaningful for practising argumentation in science classrooms and the strategies used by the teacher in this study seem to support this type of communicative approach.

In addition to lack of strategies for running group discussions, the teachers interviewed by Newton et al. (1999) pointed to advanced planning, time constraints and need of a prerequisite knowledge base as limiting factors regarding use of activities promoting argumentation. This study is an example overcoming these factors: When using existing digital teaching materials, i.e. the Viten wolf program, the planning of the teaching sequence was not more demanding than normal. In fact, one could rather say that using the wolf program shortened preparation time in terms of searching for information and planning activities since these components already were implemented in the program. Other teaching materials like textbooks, videos and CD-ROMs can also serve as basis for debates and discussions.

Regarding time, students in this study spent in total six lessons on the whole teaching sequence, which could not be considered as time consuming. In fact, it might be recommended to practice small scale activities, instead of having too high ambitions. One could argue that the web-based Viten program made this teaching especially efficient regarding time spent. However, it is important to emphasize that only two lessons were spent preparing and performing debates.

From the empirical data six reasons causing teacher interventions are identified. These are all of a general character and might be recognized in other debates regardless of issue. The reasons might help teachers predict the processes of debates and discussions. As put forward by Dillon (1994), the unpredictable nature of discussions might be an important reason why teachers don't engage their students in such activities. Another factor that might influence the predictability of activities involving argumentation is to which extent they are guided by clear goals. Things happen quickly in debates, hence directing the activity towards clear goals might be helpful. Here, the stated goals acted as guidelines for the teacher in managing the debates and as the results show, they had a strong influence on when and how she intervened in the debates.

Using role-plays as TV-debates generates multiple opportunities for practicing argumentation and might also be a good vehicle for the teacher in practicing an interactive dialogic approach to classroom discourse. Running three short debates during one class period was effective in involving many students, both in the panel and audience. Kolstø (2000) observed that role-playing increased the possibility to understand other people's point of view when one had to place oneself in their situation. Here, observations were made that students usually not very interested in science really engaged in the work with the online part and the debate. Student engagement varied from passive observers, to those playing their roles fully and making special hats to emphasize their roles as hunters.

Conclusions

It has been suggested that teachers need guidance in how to approach activities engaging students in argumentation. The contribution of this study is a typology of teacher interventions and reasons causing them. Interventions and reasons are all of a general character and transferable to other debates regardless of issue. Hence, this typology has the potential to serve as a guiding tool for teachers when preparing and conducting debates and discussions.

The main reasons explaining infrequent use of activities involving argumentation in science lessons are that teachers lack strategies for handling debates and discussions, and that such activities are both time consuming and unpredictable. The strategies used by the teacher in this study are well known and probably part of most teachers' repertoire of teaching strategies. Furthermore, experiences from this study show that it is possible to run classroom debates without spending too much time, and by running several short debates during one class period many students can be involved. Practicing small scale activities is recommended.

As for the unpredictability of debates, the typology of teacher interventions and reasons causing them offers a helpful tool in preparing teachers for situations that might occur during the debates, and how to handle them. In addition, stating clear aims for the teaching sequence will make the purpose of the teaching clear for the students and act as a tool for the teacher in managing the debates.

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Appendix 1

UNIVERSITETET I OSLO
DET UTDANNINGSVITENSKAPELIGE FAKULTET

Appendix 1

Elever og foresatte

Institutt for lærerutdanning og skoleutvikling
Postboks 1099 Blindern
0317 OSLO

Fysikkbygget, Østfløyen
Sem Sælands vei 24

Telefon: 22 85 50 70
Telefaks: 22 85 44 09
Vev-adr.: http://www.ils.uio.no/

Dato: 21.01.02

"Viten – nettbasert undervisning i natur- og miljøfag"

Universitetet i Oslo, NTNU og University of Berkeley, California, har gått sammen om å utvikle internettbaserte undervisningsprogrammer i natur- og miljøfag**.** Undertegnede har fått midler fra Utdannings- og forskningsdepartementet for å evaluere hvordan undervisningsprogrammene fungerer i skolen. Dette arbeidet skal etter hvert munne ut i en doktorgradsavhandling. Deres ungdomsskole er en av flere skoler som er valgt ut til å være med på forskningsdelen av prosjektet.

Vi skal undersøke hva elevene lærer, og forsøke å få et innblikk i hvordan de lærer ved å bruke Internett i undervisningen. For å få svar på slike spørsmål er vi avhengig av å registrere diskusjoner mellom elever når de sitter ved datamaskinene. I den sammenheng ønsker vi å gjøre lydopptak av samtaler mellom elevene når de jobber. For at vi skal ha nytte av lydopptakene må vi også vite hva elevene ser på skjermen når de diskuterer. Vi ønsker derfor å plassere videokamera bak elevene og filme dataskjermen mens elevene jobber.

Vi ber med dette om tillatelse til å foreta lyd- og videoregistrering, og trenger elevens og foresattes samtykke. Vi ber derfor om at **både** elev og foresatte skriver under den vedlagte avtalen.

All registrering, lagring og bruk blir gjort i henhold til Datatilsynets retningslinjer. All informasjon vil bli anonymisert, og kan ikke føres tilbake til den enkelte elev. Det er bare prosjektledelsen som vil se og høre opptakene.

Med vennlig hilsen

Sonja M. Mork	Doris Jorde	Torgeir Onstad
Doktorgradsstipendiat	Prosjektleder/veileder	Instituttbestyrer

Avtale

Elevens navn

	Ja	Nei
Undertegnede godtar at det blir gjort lyd- og videoopptak, samt tatt bilder med digitalt kamera i forbindelse med prosjektet "Viten-nettbasert undervisning i natur- og miljøfag".		
Undertegnede godtar at bilder tatt med digitalt kamera kan benyttes på prosjektets hjemmesider (http://viten.no), og ved presentasjoner av resultater fra prosjektet. **Kun bilder** vil bli brukt. De vil **ikke** bli koblet til navn, skole eller hjemsted. (På baksiden av dette arket ser dere hva slags bilder det er snakk om).		

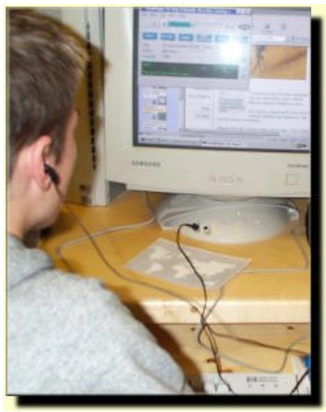
Opptak, bruk og lagring av opptakene vil bli foretatt i henhold til Datatilsynets retningslinjer. Ved publisering av resultatene fra prosjektet vil informasjon ikke kunne føres tilbake til den enkelte deltaker på opptakene.

Dato　　　　　　　　Sted

Elevenes underskrift

Foresattes underskrift

Eksempler på digitale bilder med elever i undervisningssituasjon.



Appendix 2

Appendix 2

Debate about wolves 2001

F (farmers and hunters): role to argue against wolves in the Norwegian wilderness
N (nature protector organisations): role to argue for wolves in the Norwegian wilderness
Numbers are indicating different students

Debate 1

Utterance		**Structure of argument** Disputational Reasoned disputational Cumulative Exploratory **Teacher interventions**	**Quality of content** Other Incorrect Moderate Expected	**Type of argument** Biological Economic Personal Political Other
1	**Teacher: There are two different groups of participants in the panel. One is from the Norwegian Hunter and Fisher Association (F) and the other is from the Association for Nature Protection. Now we will first hear the initial statement from the Association for Nature Protection.**	Management		
2	Student N1: Yes, we are going to present ours and not the least of which the view of the Association for Nature Protection in this ongoing discussion about wolves.	Initial statement		
	Our view is that wolves have just as much right to live as humans.	Disputational (Claim)	Moderate (Inaccurate, ethical and debated question)	Biological
	Nobody has reason to fear wolves, because they don't harm us.	Reasoned disputational (Claim with reason)	Moderate (Partly correct, wolves can harm people under certain conditions)	Biological
	And the reason that they are able to kill some sheep is simply because of the fact that farmers are not looking after their sheep.	Reasoned disputational (Claim with reason)	Expected (Free range farming is not successful in areas with large predators)	Personal
	We should leave the wolves in peace so that there will be more of them.	Reasoned disputational (Claim with reason)	Expected (Population will probably increase if wolves are left in peace)	Biological
3	**Teacher: OK, then we would like to hear the view of the Norwegian Hunter and Fisher Association in this matter.**	Management		
4	Student F2: We in the Norwegian Hunter and Fisher Association think that it is an irresponsible position to have	Initial statement		

	so many wolves in Norway.			
	It will cause an increasing problem for us real guys from the woods.	Disputational (Claim)	Moderate (Partly correct)	Personal
	Wolves might rather be moved to isolated areas outside the areas where we in the Norwegian Hunter and Fisher Association go hunting.	Disputational (Claim)	Moderate (Refers to wolf zones, but wolf zones are created to avoid conflicts between wolves and livestock)	Personal/ Political
	Wolves might bite our dogs, and we don't like that.	Disputational (Claim)	Expected (Has happened at several occasions)	Biological
	Besides, we in the Norwegian Hunting and Fishing Association have noticed a considerable decrease in the moose population, parallel with the increase in the wolf population, moose that we could have hunted and sold. Reduction in the moose population means higher prices, and nobody wants that. This is threatening to our business.	Reasoned disputational (1. sentence: claim, last 2 sentences: reason)	Incorrect (Wolf population in Norway only counts between 20-30 individuals at the moment)	Biological/ Economic
5	**Teacher: But don't you in the Association for Nature Protection have any understanding for these hunters that really have problems? Are there fewer moose to hunt, and do wolves kill their dogs?...**	Accuracy of content		
6	Student N1: In the first place, the wolf population is still at a very low level, so I can't see that you could have noticed any reduction in the moose population. The wolf population is too small in Norway.	Reasoned disputational (Counterclaim with reason)	Expected (Correct)	Biological
7	**Teacher: But it is a fact that there has been an increase in the wolf population the last years?**	Accuracy of content		
8	Student N1: Yes, of course, but they must definitively have permission to catch moose. That's their diet isn't it? Just like other predators they must catch the prey they need to survive.	Exploratory (Claim with reason, example/comparison at the end)	Expected (Correct)	Biological
9	**Teacher: How many wolves do you think we should have in Norway?**	Extending range of topic		
10	Student N1: Many, we think 500-1000.	Disputational (Claim)	Expected (Correct according to researchers if the population is going to be viable)	Biological

11	**Teacher: What do you (F) mean about this matter then?**	Level of participation		
12	Student F2: 500-1000, that's an unacceptable number of wolves. We think that we should have as few as possible. And they should be isolated from areas that are needed by people.	Reasoned disputational (Counterclaim)	Moderate (relates to what people against wolves think and wolf zones)	Personal/ Political
13	**Teacher: How are you going to do that then? Wolves are animals that wander over large areas. How is one supposed to isolate them?**	Extending range of topic		
14	Student F1: Place them on an island.	Cumulative (Continue utterance 12)	Incorrect (possible strategy to separate wolves and livestock, but unrealistic)	Political
15	Student F2: We in the Norwegian Hunter and Fisher Association have worked out a plan for this.	Cumulative (Continue utterance 14, but does not add much)	Other (No particular content)	Other
16	**Teacher: Maybe you could tell us a bit about that plan?**	Extending range of topic		
17	Student F3: Yes, we are going to take most of the packs of wolves present in Norway, and place them in one area. A quite large bounded area in a wood in the eastern part of Norway. And there we are going to try to keep them in, in a way. So that in this area we are going to have as few individuals as possible of livestock and other animals the wolves could take. But of course we must have some moose and sheep and so on, because the wolves have to learn to eat by themselves too.	Exploratory (repeat, explain, elaborate)	Moderate (Describes wolf zones, which were suggested by the government as one of the strategies to avoid conflicts between wolves and livestock, but we are not going to move wolves to specific areas or place sheep there for wolves to hunt on)	Political
18	**Teacher: (to N) Do you believe that it will be possible to limit the wolves to a restricted area?**	Level of participation		
19	Student N1: No, absolutely not. The thing is that wolves wander a lot. They are not at rest, and then you can't decide that the wolves are going to stay in one area. E.g. One example, it is almost the same with bears. They also wander. There was a killer bear here that was moved to Finland, from Norway, but after a year or something, then it was back again, so you can't do that.	Exploratory (Counterclaim with reason, backed up by an example)	Expected (draws on correct information from the program and brings in additional correct information in form of an example)	Biological

20	**Teacher: Any comments? F2** (asks for permission to speak)**?**	Management		
21	Student F2: Yes, but we were thinking an island that is big enough that they can wander freely and have a life as normal as possible, but not at the expense of our livestock.	Reasoned disputational (Counterclaim with reason)	Moderate (draws on information on separating wolves and livestock, correct that wolves need large areas to live on, suggests wolves on large islands, but that is unrealistic)	Personal/ political
22	**Teacher: But how far can wolves wander? Does anyone know that?**	Extending range of topic		
23	**Teacher: Student N2** (asks for permission to speak) **you had a comment?**	Management		
24	Student N2: Yes, to their (F-group) idea about islands; there is a different climate there. The wolves belong to the woods. There will be a colder and rougher climate.	Reasoned disputational (Counterclaim)	Moderate (different climate is correct, but normally the climate is warmer on islands)	Biological
25	Student F1: They (wolves) have to get used to that, and there is nothing more to it than that.	Disputational (Claim)	Other (On the edge of the original theme)	Other
26	**Teacher: Student N1** (asks for permission to speak) **do you have a comment?**	Management		
27	Student N1: Yes, that if… It is clear that the big islands in Norway, they are settled by humans, and then you can't move wolves there, because they (people there) are just as scared of wolves as those on the mainland…	Exploratory (because it is a part of utterance 29, which is an elaboration)	Expected (Correct that big islands are settled by humans, can assume that there is no difference between people at islands and mainland regarding fear are of wolves)	Personal
28	**Utterance 28 is an interruption of utterance 27, so utterance 27 and 29 must be considered in connection.** Student F?: But that they have no reason to…	Disputational (Claim)	Moderate (Whether people have reason to be afraid of wolves is debated)	Other
29	Student N1: … and those (islands) that are left then are just small islets without trees and food and that is not possible.	Exploratory (Part of connected to utterance 27)	Expected (Correct)	Biological
30	**Teacher: But you said that the wolves were not dangerous, is that right? (to F) Are the wolves dangerous? Do they kill humans?**	Accuracy of content		
31	Students F2: Humans are not the Norwegian Hunter and Fisher Association's biggest concern…	Disputational (Claim)	Other (Must be considered in light of the teacher in utterance 30: Avoids question, no	Personal

			particular content in utterance)	
32	**Teacher: But do wolves kill humans? Can we get that sorted out?**	Coming to a stop		
33	Student F1: It has happened…	Disputational (Claim)	Moderate (inaccurate)	Biological
34	(student N2: For 200 years ago, yes…)	Cumulative (Builds on utterance 33: confirms and elaborates)	Expected	Biological
35	F1: …and it is just a matter of time until it will happen again. But what we are most afraid of is our livestock. That there is an increase of….	Cumulative (Elaborates on utterance 34	Moderate (Impossible to know whether wolves will kill humans again)	Personal
36	Student F2: Our hunting animals (dogs) are being killed by wolves and we are worried about that.	Reasoned disputational (Claim with reason)	Expected (Correct)	Biological/ Personal
37	**Teacher: Student N2** (asks for permission to speak) **you wanted to say something?**	Management		
38	Student N2: Actually as it is nowadays, humans kill more wolves than wolves kill humans.	Disputational (Claim)	Expected (Correct)	Economic/ Personal
39	Student F2: Yes, but it isn't humans that are threatened by wolves. It is……..	Disputational (Counterclaim)	Moderate (inaccurate, partly correct since livestock are more threatened)	Biological
40	**Teacher: So wolves are not actually a threat to humans then?**	Coming to a stop		
41	Student F2: Yes, in the sense that it is not a direct threat, but a threat to the prices on food, which are increasing if moose and the other animals that we were supposed to have hunted disappear, then the prices will increase for ordinary Norwegians.	Exploratory (Counterclaim with reason, backed up by explanation)	Incorrect (Some areas have reduced number of animals to hunt, but this does not increase prices on meat)	Economic
42	**Teacher: But isn't it the same thing whether it is the wolves or humans who kill moose?**	Extending range of topic		
43	Student F2: No, because the wolves eat all the moose themselves, while humans are sharing between them.	Reasoned disputational (Counterclaim with reason)	Other (On the edge of the debated theme)	Personal
44	**Teacher: Student N1** (asks for permission to speak) **do you have a comment?**	Management		
45	Student N1: Yes, this thing about the livestock. That wolves are to be shot because they kill livestock. Actually, the reason for them to kill	Exploratory (Claim with reason, backed up by explanation and generalisation)	Expected (Correct)	Personal/ Biological

	livestock is that you don't take care of them. The wolves wouldn't be able to kill livestock if you had been taking care of them. But, E.g. shepherds, or sheep farmers that let their livestock out into the woods and woodlands without protection…. Then it goes without saying that a predator will come and kill them! That's natural, and the wolves should not be shot because of that.			
46	**Teacher: Student F3** (asks for permission to speak)**?**	Management		
47	Student F3: We can't just…… When we send flocks of sheep out into nature like that, you cannot have one person guard a flock of a couple of hundred animals at one time, you know. That is just not possible. You can't stand and guard every one of them all the time.	Reasoned disputational (Counterclaim with reason)	Moderate (Several solutions in addition to using shepherds are suggested in the program)	Personal/ Economic
48	**Teacher: But do you have too many sheep then? Might that be the problem?**	Extending range of topic		
49	Student F3: No, I would rather say that you have to look after the wolves so that they don't kill them (the livestock).	Reasoned disputational (Counterclaim with reason)	Moderate (draws on partly correct but insufficient information from the program)	Political
50	**Teacher: Student F1** (asks for permission to speak)**?**	Management		
51	Student F1: Yes, how long is it since the last time you ate meat student F1?	Disputational (Challenging question)	Other (On the edge of the debated theme)	Other
52	Student N1: It is a while yes. I don't remember just now…	Disputational (Claim)	Other (On the edge of the debated theme)	Other
53	Student F1: That you can thank the wolves for. If it hadn't been wolves in Norway, then you would have had more meat, and Norway wouldn't have to import meat. You know, Norwegian meat is the best. That is obvious. And then, if the wolves eat some of this meat, then there will be less meat, higher prices and you will have real Norwegian meat less frequently.	Exploratory (Claim with reason, elaboration and example)	Incorrect	Economic
54	**Teacher: OK, we have to take a last comment from student N1** (asks for permission to speak) **on this one, and then we have to end the debate.**	Management		

55	Student N1: Yes, what kind of meat do Norwegians eat most of? That's pork! And they are not in danger of being taken by wolves, because they are inside a barn aren't they? Pigs, and cows too are not in danger…	Reasoned disputational (Counterclaim with reason)	Expected (Correct)	Personal
56	Student F2: But there is no proof that the wolves only eat sheep….	Disputational (Counterclaim)	Expected (Correct)	Biological
57	Student N1: Yes, but that is what gives the most meat isn't it? And that is what we have the most of in the shop! And moose, yes that's good meat of course, but that isn't what Norwegians normally eat. That's more for celebrations…	Exploratory (Counterclaim with reason. Elaboration and example)	Expected (Correct)	Personal
58	Student F2: Where do you have that information from?	Disputational (Challenging question)	Other (No particular content)	Other
59	**Teacher: OK, we have to stop there. I think you have been very clever! Let's switch groups.**	Management		

Debate 2:

		Structure of argument Disputational Reasoned disputational Cumulative Exploratory	**Quality of content** Other Incorrect Moderate Expected	**Type of argument** Biological Economic Personal Political Other
	Teacher: Then we have the Association for Nature Protection on this side (N) and the Norwegian Association for Farmers (F) here. This time I think we start with the initial statement from Nature and Youth, who will tell us about their views in the wolf debate.	Management		
1	Student N2: Yes, we are for wolves, and we want them to live. The wolves are more afraid of humans than we are afraid of them. And it is part of wolves' nature to kill sheep. We have more sheep than wolves in Norway.	Initial statement Disputational (Claim) Disputational (Claim)	 Moderate (No evidence that the wolf is more afraid) Expected (Correct)	 Biological Biological
2	**Teacher: Mhmm, and then we want to hear the initial statement from the Norwegian Association for**	Management		

	farmers:			
3	Student F1: Now I will present the opinion we farmers have. We think that the wolves are a threatening predator and should be shot. We will not have wolves in Norway, they kill our sheep and we are suffering economic losses. They kill other animals that we also should have had, e.g. moose as mentioned here earlier. So we think that wolves should be shot.	Initial statement Disputational (Claim) Reasoned disputational (Claim with reason)	 Expected (Correct) Expected (Correct	 Biological/ Personal Biological/ Economic/ Personal
4	**Teacher: But what do we say to… Yes, a comment on that student N1**(asks for permission to speak)**?**	Management		
5	Student N1: It is they (the wolves) that kill fewer sheep compared to other predators. It is wolverine, golden eagle and those; they kill many more sheep than wolves do.	Reasoned disputational (Counterclaim with reason	Expected (Correct)	Biological
6	Student F1: Not in the area where I have my farm. I'm a farmer and I have 200 sheep. And every once and a while I find cadavers here, killed by wolves. I have never found cadavers killed by other predators than wolves. It isn't bears or other animals.	Reasoned disputational (Counterclaim with reason)	Expected (Correct)	Personal
7	**Teacher: But how do you know that a sheep is killed by a wolf?**	Extending range of topic		
8	Student F1: Well, once I brought an expert with me to look at the footprint and how the sheep was killed. It was bitten in the throat and so on, and since then, I have learnt to recognise the signs from attack by wolves myself. And they have almost like dog footprints, so you can see that it isn't a bear so to speak.	Exploratory (Explanation, elaboration, comparison)	Expected (Correct)	Biological
9	**Teacher: But how many sheep can you loose in one season?**	Extending range of topic		
10	Student F1: Up to 30-40 sheep and that is a considerable loss from a stock of 200.	Exploratory (evidence backed up by explanation)	Moderate (not realistic that all the lost sheep are killed by wolves)	Economic/ Personal
11	**Teacher: But how… are they killed at once or how does that look?**	Extending range of topic		
12	Student F1: Well, they are chased (hunted). And some	Reasoned disputational (Claim	Incorrect	Biological/ Personal

	times they actually die of fear because sheep can do that. If they are very frightened they can die of fear.	with reason)		
13	**Teacher: Doesn't that sound terrible (To N-group)? It must be terrible to find their livestock that they have a relationship to, killed by wolves?**	Level of participation		
14	Student N4: You don't have a relationship to your animals if you release them out in the woods and just let them go there on their own. Either you must look after your livestock, or you must find something else to do!	Reasoned disputational (Claim with reason)	Moderate (True that livestock must be looked after, not true that farmers don't care)	Personal
15	**Teacher: Comment from Student N1** (asks for permission to speak)**:**	Management		
16	Student N1: Yes, when you let your animals out in the nature there will certainly be predators there, and you must take the consequences of that!	Cumulative (Repeats, confirms, elaborates)	Expected (Correct)	Biological
17	**Teacher: Student N3** (asks for permission to speak)**?**	Management		
18	Student N3: Yes, I was going to say the same thing.	Cumulative (Confirm)	Expected (Based on the content in utterance 16)	Biological
19	**Teacher: Yes, what do you say about this (to A-group)?**	Level of participation		
20	Student F1: Yes, of course, but the fact is that we are getting very small amounts of money from the government…… for support…. So we can't afford to do something else. We can't afford paying wages to shepherds and things like that. So that is the only solution if the animals are going to graze.	Reasoned disputational (Counterclaim with reason)	Moderate (There are other solutions, suggested in the program)	Economic
21	**Teacher: But isn't it a pity, because the wolves are important parts of the ecosystem too, aren't they?**	Extending range of topic		
22	Student F2: No, absolutely not!	Disputational (Claim)	Moderate (Must be seen in light of the teacher in utterance 21. Small population in Norway, so probably not much influence on the ecosystem)	Personal
23	**Teacher to N-group: Have you anything to say to**	Coming to a stop		

	that? …… Which function do wolves have exactly? Why do you want to protect them?			
24	Student F1: Yes, why should we have wolves?	Disputational (Challenging question)	Expected (legitimate question as population has minimal biological influence)	Personal
25	Student N3: They are a part of Norway then…….	Disputational (Claim)	Moderate (inaccurate)	Biological
26	Student N1: The wolf is an endangered species, and we would like to protect the species we have in Norway.	Reasoned disputational (Claim with reason)	Expected (Correct)	Political
27	Student N2: The wolves are in danger of going extinct, and the sheep are not.	Cumulative	Expected (Correct)	Political
28	Student F1: But, if the wolves are a part of Norway, why are people living in areas with wolves afraid of going out, and letting their children go out?	Disputational (Challenging question)	Moderate (Correct that some people are afraid of going out because of the wolves)	Personal
29	**Teacher: Yes, have wolves ever killed humans?**	Extending range of topic		
30	F1: Yes, they have, but of course that's quite a long time ago. BUT, then it is only a question of time before it happens again.	Disputational (Claim)	Moderate (Correct that it is a long time ago, but we don't know whether it will happen again)	Biological
31	Student N1: The wolves are more afraid of humans than we should be of the wolves.	Disputational (Counterclaim)	Moderate (Wolves are shy, but we don't know whether wolves are more afraid than humans)	Biological
32	**Teacher: Yes? (to F-group)**	Management		
33	Student F1: Wolves have been close to houses and killed dogs tied up to the house. And then I don't understand that wolves are so afraid of humans.	Exploratory (Challenge in the last sentence is backed up by evidence in the first sentence)	Expected (Correct)	Biological
34	Student N1: But wolves haven't killed humans.	Disputational (Claim)	Incorrect	Biological
35	Student F1: No, but they are obviously very close (to peoples houses).	Disputational (Counterclaim)	Expected (Correct)	Personal
36	**Teacher to N-group: But isn't it so that the wolves are one of the most dangerous animals we have in Norway, with regards to killing people?**	Extending range of topic		
37	Student N1: It is more than 200 years since wolves killed a human. If you drive your car into a moose you could die	Exploratory (Facts backed up by a comparison)	Expected (Correct hat it is 200 years since wolves killed humans in Norway)	Biological

	from that too.			
38	**Teacher: Yes, then you are all uncompromising, both groups. And none of you want to change views? Can't you meet half way then? How can we find a solution to this conflict? Can we solve it in a way and come to an agreement?**	Extending range of topic		
39	Student N4: Only a small comment to this about wolves coming to peoples houses and killing dogs. That's absolutely true. And then it is wrong to say that they don't kill humans, because they may well do that. This is why I think the people living in areas with wolves should build fences against them, or watch out better. Because they (wolves) might definitely kill humans as well.	Exploratory (Confirm utterance from opposite group, offer alternative solution)	Expected (Correct)	Biological
40	Student F1: But that is not very nice then, that one should…. Yes, one has bought a new house then, in an area with wolves, and then you have to buy huge barbed wire fences. That isn't exactly pretty though…..	Reasoned disputational (Counterclaim with reason)	Other (Other) (On the edge of the debated theme)	Personal
41	Student N4: You don't have to have huge barbed wire fences. When you buy (a house) in an area like this, then you know that there is a lot of woodland (or forest). And then I'm sure you are told, because it says so in Norwegian laws, that you are going to be told about the risks when you are buying something, and then you are told that there are wolves in the area. And then it is a natural thought to build fences to keep the wolves out.	Exploratory (Counterclaim with reason, backed up by elaborations and explanations)	Moderate (Partly correct, but inaccurate)	Personal
42	**Teacher: Student N3** (asks for permission to speak) **has a comment:**	Management		
43	Student N3: Yes, before someone moves to an area with wolves, they should think about the risk they are taking. And wolves have just as much right as humans to stay here in Norway.	Cumulative (Repeat, confirm, elaborate)	Moderate (Correct about risk, last part is debatable)	Personal/ Biological
44	**Teacher: Student F1** (asks for permission to speak) **has a comment to that?**	Management		
45	Student F1: Yes, that…… I don't mean that ….. let us say	Exploratory (Example backed up by facts)	Expected (Correct that wolves wander	Biological

	that you move to an area where there are no wolves, but then wolves turn up. Because wolves really are wandering animals. Then they come to a new place.		and might establish in a new territory, or vagabond wolves might turn up)	
46	Student N4: But that's…. the wolves they do keep….	Disputational (Claim)	Other (Unfinished sentence without particular content)	Other
47	Student F1: You cannot think like this; that "no, I can't live next to a forest in case predators are going to settle there". That is not possible.	Cumulative (repeat, confirm from 45)	Moderate (There is certain knowledge about where predators settle, but whether it is reasonable to think like this when buying houses is hard to evaluate)	Personal
48	**Teacher: Student N1** (asks for permission to speak)**?**	Management		
49	Student N1: The wolves have their own territories, and they mainly stay there. And then you will probably be warned that there is a wolf territory there, and then you must take that into consideration.	Exploratory (Claim with reason and suggestion to consider risk)	Expected (Correct)	Biological
50	**Teacher: Student N3** (asks for permission to speak)**?**	Management		
51	Student N3: Yes, you are saying that the wolves move. Aren't we moving also? We move just as much as the wolves….	Disputational (Challenging question)	Other (On the edge of the original theme)	Other
52	Student F1: Yes of course, but there are certain differences between humans and wolves, really.	Reasoned disputational (Counterclaim with reason)	Moderate (Inaccurate)	Other
53	**Teacher: To interrupt you a bit here, how many wolves do you mean that we should have in Norway? How many wolves do you (F-group) mean that we should have? Realistically?**	Debate off track		
54	Student N4: Between 1000 and 500, because we must have about 500 animals to get a viable flock in a way….	Reasoned disputational (Claim with reason)	Moderate (Correct, except the concept of flock instead of pack)	Biological
55	**Teacher: What do you actually mean by viable flock?**	Accuracy of conte nt		
56	Student N4: Yes, not flock, but in a way the whole…	Cumulative (repeat, elaborate)	Moderate (inaccurate)	Biological
57	**Teacher: Stock?**	Extending range of topic		
58	Student N4: Yes.	Cumulative (confirm)	Expected (Correct reference to 57)	Biological
59	**Teacher: What does viable stock mean then?**	Extending range of topic		

60	**Teacher: What will happen then if the number is below the number you mentioned now?**	Extending range of topic		
61	Student N4: It depends on how much below then, but if it is down to……	Disputational (Claim)	Moderate (inaccurate)	Biological
62	**Teacher: Let's say that there are 30 wolves left for instance, in all of Scandinavia. Is that enough?**	Extending range of topic		
63	Student N4: No, then there wouldn't be those mating opportunities and everything strange like that.	Reasoned disputational (Claim with reason)	Expected (Correct)	Biological
64	**Teacher: What might that lead to then?**	Extending range of topic		
65	Student N4: They die out…..	Cumulative (Elaborate on previous utterances)	Moderate (in accurate)	Biological
66	**Teacher: Yes?…..**	Management		
67	**Teacher: Questions from the audience?**	Management		
68	Audience: They can get more ears….	Cumulative (Elaborate on previous utterances)	Moderate (inaccurate)	Biological
69	**Teacher: Yes, what do we call it when...**	Extending range of topic		
70	Audience: Inbreeding then…	Cumulative (Elaborate on previous utterances)	Expected (Correct)	Biological
71	**Teacher: Yes, if we have very few animals in a stock we can get inbreeding, yes.**	Extending range of topic		
72	Audience: Sisters and brothers mate….	Cumulative (Elaborate on previous utterances)	Expected (Correct)	Biological
73	**Teacher: Is that favourable?**	Extending range of topic		
74	Audience: No.	Cumulative (Elaborate on previous utterances)	Expected (Correct)	Biological
75	**Teacher: How can we prevent that from happening?**	Extending range of topic		
76	Student N3: Let the stock increase.	Cumulative (Elaborate on previous utterances)	Expected (Correct)	Biological
77	**Teacher: Student F1** (asks for permission to speak)**?**	Management		
78	Student F1: We can prevent that by killing all the wolves, then we eliminate the whole problem. That's quite simple though.	Reasoned disputational (Claim with reason)	Other (on the edge of the original theme)	Personal

79	**Teacher: Then I think we should stop there and switch groups.**	Management		

Debate 3

		Structure of argument Disputational Reasoned disputational Cumulative Exploratory	**Quality of content** Other Incorrect Moderate Expected	**Type of argument** Biological Economic Personal Political Other
1	**Teacher: Then I think the group from the Norwegian Association for farmers should start. What do you mean about this matter?**	Management		
2	Student F1: Yes, we are against wolves, and that wolves should be here.	Initial statement		
	Because the sheep are the life for the farmer and wolves are ruining that life.	Reasoned disputational (Claim with reason)	Moderate (Partly correct for some farmers)	Personal
	Our small children want to be outside playing peacefully, but that is not possible because they are afraid of the wolves.	Reasoned disputational (Claim with reason)	Moderate (Partly correct for some farmers)	Personal
	We don't have time to look after our sheep. We have to look after the farm and the fields and other things. And everything was just fine until the wolves showed up. Our sheep ….	Reasoned disputational (Claim with reason)	Moderate (Partly correct for some farmers)	Personal
	We have a relationship to our animals. We know them and we have named them. And then we find them completely destroyed by wolves. How do you think that feels? We are devastated! We were just fine until the wolves showed up.	Reasoned disputational (Claim with reason)	Moderate (Partly correct for some farmers)	Personal
	The wolf is not a Norwegian animal and it does not belong here.	Disputational (Claim)	Incorrect	Personal
3	**Teacher: Then perhaps we might hear the view of the Association for Nature Protection?**	Management		
4	Student N3: Eh…..	Initial statement		
5	**Teacher: Are you for wolves?**	Coming to a stop		
6	Student N3: Yes, we are for wolves.	Initial statement		
7	**Teacher: Why are you for wolves? Can you say something more about that?**	Extending range of topic		

8	Student N3: Because they have just as much right to be here in this country as we have. They (F-group) said that the wolf isn't a Norwegian animal, but that is not true, because the wolves have been here much longer than we have been here. Why should they be removed when we have been here for a much shorter period of time?	Reasoned disputational (Claim with reason)	Expected (Whether wolves have a right to be in Norway is at the core of the conflict and a debated theme, but according to the Bern convention we are obliged to protect endangered species like the wolf. Probably true that wolves were established in Norway before humans since they historically had the largest distributions of all land living animals in recent historical time)	Biological
9	**Teacher: Student N4** (asks for permission to speak)**?**	Management		
10	Student N4: You said that "when the wolves came"…. The wolves have always been here. You came….	Cumulative (Repeats, confirms)	Moderate (Inaccurate)	Biological
11	**Teacher: Do you have any comments to that (F-group)?**	Coming to a stop		
12	Nobody answers….			
13	**Teacher: But do you (N-group) understand that it is a problem for them that the wolves are eating their livestock? It must be horrible to find their livestock eaten by wolves.**	Coming to a stop		
14	Student N3: We do have examples that Polish shepherd dogs have been used to watch sheep.	Disputational (Claim)	Expected (Correct)	Political
15	**Teacher: Yes, there is a research project going on with shepherd dogs. A comment from the audience** (asks for permission to speak)**?**	Management		
16	Audience: Yes, actually if you mean that the wolves should be shot if they kill so called livestock….. We are against death penalty in Norway, so if a person kills another person here, then it is 21 years in prison….	Reasoned disputational (Claim with reason)	Other	Political/ Other
17	Student F1: There are differences in animals and humans though…	Disputational (Counterclaim)	Moderate (Inaccurate)	Other
18	**Teacher: Do you (F-group) have a comment to what**	Debate off track		

	student N3 said?			
19	Student F1: Yes, we don't have time for training dogs while we are working with our fields and all the other animals and while we are looking after the sheep.	Reasoned disputational (Counterclaim with reason)	Incorrect (Shepherd dogs are already trained by professionals before they are sold)	Personal
20	**Teacher: Student N3** (asks for permission to speak)**?**	Managment		
21	N3: Those dogs are already trained.…..	Disputational (Counterclaim)	Expected (Correct)	Political
22	**Teacher: Audience** (asks for permission to speak)**?**	Management		
23	Audience: If you now are losing so much (money) because the wolves kill your sheep, then you have to start counting! Then you should find out how much it costs to train and take care of a shepherd dog or a shepherd and then you should make a comparison. I bet that it is much cheaper to train a dog and a shepherd than letting the wolves kill your sheep.	Reasoned disputational (Claim with reason)	Moderate (Correct to focus on economic balance but the example is not good)	Economic
24	**Teacher: Isn't it so that you get compensations from the government if your sheep are killed by wolves? Aren't you paid an amount of compensation then?**	Extending range of topic		
25	Student F1: Yes, but then we save money for the government if we shoot the wolves then.	Reasoned disputational (Claim with reason)	Moderate (Hunting wolves is also expensive)	Economic
26	**Teacher: Audience** (asks for permission to speak)**?**	Management		
27	Audience: Yes, the Norwegian Association for farmers; why…… the Swedish farmers they make an effort to avoid that wolves kill sheep. But Norwegian farmers do not, for instance they (the Swedish farmers) have big areas that they fence with electric wires, so when the wolves try to get over, they can't, and then the wolves get respect (for the fence) and stay away. Why shouldn't Norwegian farmers do something? They just let their sheep out and expect that they are coming back. It is obvious that predators will catch another animal that isn't very good at running etc. Why shouldn't Norwegian farmers try to do something about wolves killing their sheep? You	Exploratory (Example backed up by facts)	Moderate (Few sheep in Sweden, fences are also common in Norway)	Personal/ Biological

	only sit on your asses and want the wolves shot. That's…….			
28	**Teacher: Then student F1** (asks for permission to speak) **will comment:**	Management		
29	Student F1: Yes, why should we do something about it then? It's much easier to just shoot them then. Then we don't have to do something. If we are going to sit and make a lot of hullabaloo to look after the wolves. It's much easier to just shoot them.	Reasoned disputational (Counterclaim with reason)	Moderate (Not incorrect, but it is not very nuanced and is against the law)	Personal
30	**Teacher: Why is it important to have wolves in Norway student N4?**	Level of participation		
31	Student N4: It's our culture. They have been here longer than us. It's a Scandinavian animal that is threatened by extinction, and it's special for our culture.	Reasoned disputational (Claim with reason)	Expected (Correct)	Biological/ Political
32	**Teacher: Student N2** (asks for permission to speak)**?**	Management		
33	Student N2: If you have heard about the Bern convention, which is an international agreement, where we have signed an obligation to take care of all animal species that are threatened.	Exploratory (Explains and elaborates)	Expected (Correct)	Political
34	**Teacher: Yes, what do you (F-group) say to that? We have an obligation to the international community to take care of threatened species, and the wolf is a threatened species. Are we going to break international agreements?**	Extending range of topic		
35	Student F1: But that is theirs, it is we that have to do what we want…. OK, we have signed it, but it is still our problem. Then we have to do what we think is most fair then.	Reasoned disputational (Counterclaim with reason)	Incorrect	Personal/ Political
36	**Teacher: Yes, does the Norwegian Association for farmers think it is OK to break an international agreement that Norway has signed?**	Extending range of topic		
37	Student F1: No, but then we shouldn't have signed it in the beginning.	Reasoned disputational (Counterclaim with reason)	Expected	Political
38	**Teacher: Student N2** (asks for permission to speak)**?**	Management		

39	Student N2: Yes, but if there are very few wolves at all. If you shoot one every once and a while, then it will be a very small pack. And if there is a small pack, then there will be inbreeding, and then the stock isn't big enough so that they could mate without inbreeding then. Then we will get wolves with four feet and three ears and things like that then, that's….	Exploratory (Explain, elaborate, give examples)	Expected (Correct)	Biological
40	**Teacher: Yes, what do you (F-group) say about that? Do you see the problem with inbreeding, you have animals yourselves and must know that one need out breeding, and not only have mating inside the pack. Do you have any comments on that?**	Coming to a stop		
41	Student F1: Yes we see what they mean then. Our biggest problem is the sheep. It's first and foremost what we think of.	Disputational	Other	Personal
42	**Teacher: But can one meet half way? Are there any solutions on this, so that both those who want wolves in the country can have that, and those who want to have livestock can do that? Are there any solutions to that? Student F4** (asks for permission to speak)**?**	Extending range of topic		
43	Student N4: It is possible to find an arrangement where there are wolf zones that are more limited.	Exploratory (in response to the teacher: suggests alternative solution)	Expected	Political
44	**Teacher: What do you mean by wolf zones? It might be someone that doesn't know?**	Extending range of topic		
45	Student N4: Wolf zones are zones where wolves live without many people, so that it doesn't create problems.	Cumulative	Moderate (inaccurate explanation. Wolf zones are zones without much livestock, not necessarily without humans. The point is that wolves will be protected in the zone but not outside.	Political
46	**Teacher: Is it a possibility that you can agree to (To F-group)? If one decides that certain areas, wolf zones, where one might not have livestock, but lets wolves**	Extending range of topic		

	live freely. Might that be a possible solution?			
47	F1: Yes, yes, as long as they are far away from us so.	Reasoned disputational (Claim with reason	Moderate	Personal
48	**Teacher: Audience** (asks for permission to speak)**?**	Management		
49	Audience: Yes, the so called wolf zones, I think they will fail. Because it is a fact that wolves wander, and then they will wander to the old places wouldn't they? But of course, they have territories, I know that, but then there are these "vagabond"-wolves that part from the flock and wander freely. Then it creates a family with another wolf that it meets you know? And then you have another flock. And this is not in the same territory and not in the wolf zone. It can move to another place can't it?	Exploratory (Counterclaim with reason, explains, elaborates, give example)	Expected (Correct)	Political/ Biological
50	Student N4: In the Norwegian country there are….. on the European roads along the country, at the side of the wolf barrier there are fences and barriers and there are only small openings where the wolves can cross. The wolves have to wander over huge areas to find those openings. And that makes it harder for them to wander.	Reasoned disputational (Counterclaim with reason)	Incorrect (wolves preferably avoid barriers, but there are no such barriers along the European roads in Norway)	Political
51	**Teacher: Student F1** (asks for permission to speak)**?**	Management		
52	Student F1: Yes, if you care so much about the wolves, it isn't exactly a very good life for them in captivity. Then you could just as well shoot them. If they live and are caught by fences….	Exploratory (gives reason, suggests an alternative solution)	Expected (Correct)	Biological/ Personal/
53	Student N4: They don't live in captivity, they live on 300 km.	Reasoned disputational (Counterclaim with reason)	Incorrect	Political
54	Student F1: Yes, but they are wandering animals, you said it yourself… They like to wander. It (to be caught) is against their nature.	Reasoned disputational (Counterclaim with reason)	Expected (Correct)	Biological
55	Student N4: Yes, we are not against them wandering, but they are allowed to wander. They are allowed to wander in a restricted area.	Cumulative (Repeats, confirms)	Expected (Correct for wolf zones, as they refer to here)	Biological/ Political
56	**Teacher: Then we end the debate here.**	Management		