Virtual Environments in Science

Viten.no

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Forsknings- og kompetansenettverk for IT i utdanning (ITU) ble opprettet som en del av KUFs handlingsplan om 'IT i norsk utdanning 1996-99', og ble videreført for en ny fireårs periode under handlingsplanen 'IKT i norsk utdanning, Plan for 2000 – 2003'.

Hovedaktiviteten til ITU har vært å sette i gang forsknings- og utviklingsprosjekter innen feltet IKT og utdanning. Mellom disse aktivitetene har ITU også fungert som en nettverksnode mellom ulike forskningsmiljøer i Norge.

ITU fokuserte i sin første periode på begrepene læring og kommunikasjon innenfor skjæringspunktet av teknologi, pedagogikk og organisasjon, med vekt på teknologiens rolle som katalysator for endring innen det tradisjonelle utdanningssystemet. Erfaringer fra denne perioden knyttet til ulike endringsperspektiver er systematisert og utdypet gjennom erfaringene fra prosjektene som avsluttes i den nåværende perioden.

Skriftserien omhandler ulike typer tekster som har til felles at de tar opp utfordrende perspektiver relatert til IKT og utdanning. Det gjelder utredningsarbeid, prosjektrapporter og artikkelsamlinger. ITU har, gjennom skriftserien, som siktemål å bidra til systematisk kunnskap om IKT og utdanning, samt å skape debatt og refleksjon om de utfordringer vi står overfor.

Vi håper med dette at skriftserien kan bidra til å presentere nye perspektiver på fremtidens utdanningssystem.

ITU, oktober 2003.

Preface

The following report is about science educators learning how to work with web-based learning environments for the development of science curriculum. What started as a small project looking at possibilities within this exciting new field has become a national curriculum development project spread throughout Norway.

Viten.no is a web site designed for science teachers and their students. Viten was funded by ITU for a three year period, during which time the program library has expanded to include 12 completed programs with others on the way. We believe the Viten programs contribute to improving if not enhancing how science is taught and learned.

The Viten project is also a research project looking into the implementation of ICT in science classrooms. We have been working closely with teachers and their students to understand how ICT contributes to the teaching and learning of science.

Specific Viten programs have been funded by the Department of Education and other funding organizations also interested in communication science through information technology.

We have been a small project group working with the Viten project. However, as you read this report you will soon discover that small groups can also be very productive ones. We have learned so much over the past three years as we have combined our skills as science educators together with web-based technology. However, the more we learn, the more we realize how much more there is to do. We truly hope that this report only represents the beginning of better things to come.

Our thanks to ITU and others for believing in this project and for making it possible for such a wonderful group of people to be able to work together.

Doris, Alex, Øystein, Wenche and Sonja
September, 2003

Summary of results:

- The US WISE concept has been successfully adapted and implemented in Norway. The WISE learning environment, curriculum and assessments are all designed according to the *Scaffolded Knowledge Integration* framework. This framework has been continuously refined in the United States through years of classroom trials, comparing different versions of technology tools, different approaches to guidance, and different designs for curriculum. Viten has adapted the framework as a basis for all programs.
    - The *Cycles of Malaria* project was the first Viten program. The project was translated into Norwegian and implemented for the first time in Norway in the fall of 1999. The Norwegian project included minor changes taking into account language when providing net based information. The US project concludes with an on-line debate about where the emphasis should be placed when considering plans to control the spread of malaria in the world. Our Norwegian classroom trials of the on-line debate were unsuccessful so that the Norwegian project concludes with an electronic newspaper activity in which students write articles on methods of control and create an online newspaper about malaria.
    - The development of Norwegian WISE programs promoted the start of international comparative research between the United States and Norway as teachers in different countries implemented the same programs (Cycles of Malaria and Wolves). Our findings made us aware of the differences in school culture we experienced between the two countries. Differences in localization issues were related to the presence of a national curriculum in Norway as opposed to standards based curriculum based on assessment in the US. Whereas Norwegian teachers and students have experience with project work, schools in the US are much more rigid with regards to scheduling and defining clear roles for teachers and stu-

dents. Norwegian schools had better equipment and more net connections that in the US schools. Common to both countries was the shared enthusiasm shown by students using WISE programs, expressing a continuing desire to have more net based curriculum materials in school.
    - Viten.no is now a recognized site for teachers using web-based science curriculum materials. The project has been able to expand its curriculum library with funding from parties interested in developing web-based school curriculum directed towards special interests
- Scientific literacy linked to computer literacy leads to an informed public. By connecting scientific literacy to computer literacy, we empower students with the tools necessary to engage in life long learning for responsible decision making.
    - Using appropriately developed software tools, we are able to engage students in reflection and peer discussion thus allowing increased use of discourse in the science classroom. Language and science are very much associated in the learning process as students are introduced to new ideas and then allowed to talk about them to internalize their meanings.
    - The teacher will become the hub of many divergent activities going on within a science classroom where students are asking questions not necessarily directed towards the teacher, rather to each other or someone not even present. The teacher's role will be to help students understand scientific concepts through scaffolded discussion and presentation related to information they have accessed either through the Internet or other available resources.
- The main aim for all Viten programs is that students should learn about the processes and products of science. 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

- The Viten framework draws upon theories and research about the importance of teaching science in a context, the social construction of knowledge, the importance of talking science, use of different learning strategies and the importance of communicating with the language and symbols of the youth culture.
- Viten programs are complex structures that are not just teaching about scientific content, though that is an important part of it. They are teaching about something that goes beyond the content; they are teaching about education for citizenship in a scientific context, they are teaching about scientific literacy, about decision-making on scientific issues, and they are teaching about evaluation of the presentation of science in the media.
- The Viten programs aim to promote student learning at the individual level as well as in a group structure where 2-3 students work together at a computer. In addition all Viten programs have goals related to promoting lifelong learning skills and cross-curricular activities. If we look at the wolf program, students are not just learning about a socio-scientific controversy in the Norwegian society. No, they are learning much more than that. They are learning what it means to participate in this debate by constructing arguments, by refuting arguments, and drawing upon evidence, looking critically at evidence. This debate also illustrates how language is one of the most important tools we have for supporting learning, and that being able to use scientific information in a real world context is important for student achievement.
- The Viten project is in an exciting phase where results from classroom research studies are influencing our decisions as curriculum developers. However, as we find answers to some of our questions, dozens of new questions arise. We realize that there is a considerable need for further research; especially larger scale

studies that can tell us about the impact of learning environments like Viten in science classrooms.

- Two examples demonstrate how the Viten team uses information obtained from classroom research to learn about how Viten programs are implemented. Our model of curriculum development is continuous, making use of classroom implementation studies for feedback. Such information is extremely valuable for making revisions of existing Viten programs, helping us to understand what works and what needs to be improved. Our curriculum development model is an expensive one since we require technical expertise, pedagogical and subject expertise and finally teachers and their students in real classrooms to verify if programs are reaching their goals. We believe this model is justified if we are to continue to deliver quality web-based science curriculum to teachers and their students.
- Because Viten is a net based curriculum, we are able to make records of how the projects are being used by teachers and their students throughout Norway. We are also interested in using numbers to provide information on how curriculum may be improved to better meet the needs of science teachers and students.
  - In this chapter we have followed the electronic trail left by users of the Radioactivity program in Viten to help us better understand how the project is used by students throughout Norway. The numbers reported tell a story of how students navigate through the activities of the program. This is our first attempt at following the data provided by server information to help us understand how Viten is used in classrooms, and we suggest that development of the tool should be pursued further.
  - In our interpretation of the data we find valuable information on how we might improve the curriculum in future revisions. We find new and interesting research questions as well. It would be very useful to monitor how the users navigate through the program, following their movements backwards and forwards as they solve the different tasks. Such information may tell us how they

learn and think, and in the long run help us to make (even) better programs.

- As to the present study it is obvious that many of the users don't follow the program entirely as intended from Viten. However, the program is popular and the fact that teachers choose to use the program year after year indicates that it is an important contribution to the curriculum in science teaching. We have the chance to combine quantitative studies as reported in this chapter together with qualitative classroom studies to try to explain the significance some of our findings.
- Of particular importance we can mention the following 4 pieces of evidence that concern us from a study of how the Radioactivity program has been used:
- 64% of the students work alone
- The is a steady decline from the number of students starting the program to those finishing the final activity
- A large number of the groups use 30 minutes or less to write the newspaper article
- A large number of the groups use less than two periods on the program

We have also studied the following perspectives: Gender perspectives, The nature of science perspective and pedagogical issues. We have learned the importance of texts and graphics concerning these perspectives.

1
Introducing ICT into the Science Curriculum

Science teachers have always been interested in new technologies; information technology is no exception. They were often the teachers introducing computers into schools and searching for applications for experimental and other educational uses. Some of the first applications developed for schools were simple simulations demonstrating principles of mechanics for Physics classes. Later, with the introduction of the Internet, science teachers were eager to create web pages and connect students to sites throughout the world. Pictures from NASA quickly found their way into science classes as our knowledge of the universe expanded while our abilities to communicate information made the world seem like a smaller place.

We choose to begin our story with science teachers and their students since they are the real drive behind the activities of the Viten project in Norway. As science educators we share the creative drive of science teachers to make science teaching and learning exciting and challenging. With the introduction of computers into classrooms we quickly recognized the need to explore the possibilities this new technology could provide to science instruction. We were eager to be participants in these dynamic developments and choose to look towards other projects that could help us to become involved in the latest trends in the use of information technology in schools.

Our story begins when researchers Doris Jorde (UiO) and Alex Strømme (NTNU) travelled to the University of California, Berkeley where they were introduced to the WISE (Web-based science environment) project under the direction of Dr. Marcia Linn[1]. The WISE project was at the forefront of innovations with the use of web-based applications in the development of science curriculum. After a year of emersion into the WISE project during 1998-99, Norway was

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1 The WISE project: http://wise.berkeley.edu

chosen to be the first country to implement WISE outside of the United States as researchers were interested in looking at issues of localization. Would it be possible to translate a web-based science curriculum developed in California to Norwegian for implementation in Norwegian schools? Would the technology provided by the WISE project be robust enough to service the needs of Norwegian schools? Is it possible for curriculum to be exchanged between countries?

The WISE project in Norway was eventually funded by ITU during the period 1999-2002. The project began in Norway with a concentration on the development of curriculum projects written in Norwegian and adapted to the Norwegian school system. Research into the implementation of WISE projects closely followed as we studied how teachers and their students integrated ICT into their science classes. Eventually a Norwegian version of WISE was developed called Viten[2]. The Viten platform builds on the WISE model of pedagogical software for teaching science. Viten programs are designed to present web-based science to students in grades 8-11, with topics taken from geology, physics, mathematics, biology and chemistry.

In the following chapters we tell the story of the introduction of Web-based curriculum into science classrooms in Norway. We write about the development of the Viten platform, the many different curriculum projects we have created, the implementation studies of teachers and their students and finally our experiences about the expertise we have built up (our mistakes and our successes) while learning how to present science through this powerful new mode of communication. The journey has truly been challenging and exciting!

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2 The Viten project: http://viten.no

1.1
The Web-based Integrated Science Environment

The Web-based Integrated Science Environment (WISE) project has been developed over a 15 year period at the University of California, Berkeley with funding from the National Science Foundation. The integration of computers and later web-based applications has been the focus of the Berkeley research group which grew out of the Computer as Learning Partner (CLP)[3] project (Linn 1991) and the Knowledge Integration Environment (KIE)[4] project (Linn 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.

1.1.1
The Wise Pedagogical Framework

The WISE learning environment is developed to help scaffold students as they perform innovative science inquiry projects. WISE builds on the idea that science activities should engage students in the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments. The goal is to help students become lifelong learners of science, critiquers of information, and collaborators in argument and design.

The WISE learning environment, curriculum and assessments are all designed according to the *Scaffolded Knowledge Integration* framework. This

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3 Computer as Learning Partner: http://www.clp.berkeley.edu

4 Knowledge Integration Environment (KIE): http://www.kie.berkeley.edu

framework has been continuously refined in the United States through years of classroom trials, comparing different versions of technology tools, different approaches to guidance, and different designs for curriculum. The framework thus synthesizes research findings and captures the intricacies of science education in the classroom. By encouraging learners to connect new ideas and perspectives to their previously held ideas about the scientific phenomenon they are investigating, the framework promotes cohesive understanding. Students compare, contrast, critique, sort out, and reconceptualize their scientific ideas, incorporating new information, evaluating alternative accounts, and connecting everyday ideas with scientific ideas.

The *Scaffolded Knowledge Integration* framework includes four major principles that guide the design of successful inquiry activities and technologies.

- **Make science accessible**: Inquiry curriculum requires an appropriate level of analysis for the scientific content so that students can restructure, rethink, compare, critique, and develop more cohesive ideas.
- **Make thinking visible**: Inquiry curriculum should challenge students to articulate what they know and mean about scientific topics so that they are able to restructure their thinking when new ideas are presented.
- **Help students learn from each other**: Inquiry curriculum should include opportunities for collaboration, discussion and debate, enabling students to articulate their own ideas for their peers, as well as to receive and exchange feedback.
- **Help students develop autonomous learning skills**: To help students become autonomous science learners, inquiry curriculum can enable the development of lifelong learning skills such as critiquing evidence, debating arguments, or designing solutions to personally relevant problems.

Typical projects engage pairs of students in *designing* solutions to problems (e.g., designing a space ship allowing astronauts to grow plants onboard), *debating* contemporary science controversies (e.g., should we have wolves in Norway?), or *critiquing* scientific claims found in web sites (e.g., should we support vaccine or pesticide research for Malaria control?)

Figure 1.1 displays the WISE interface where students navigate through activity steps in the left-hand frame of their Web browser, called the "Inquiry Map." Each step in the project can result in the display of Web pages (e.g., to be used in support of student designs or debates), in the appearance of the WISE notes window, an online discussion, or any one of numerous inquiry tools (e.g., Java applets for data visualization, simulations, and causal maps). As the students work through the sequence of activities that comprise the project, the teacher circulates within the classroom, interacting with one small group of students at a time, helping them interpret Web materials, reflect on the topic and interact with their peers.

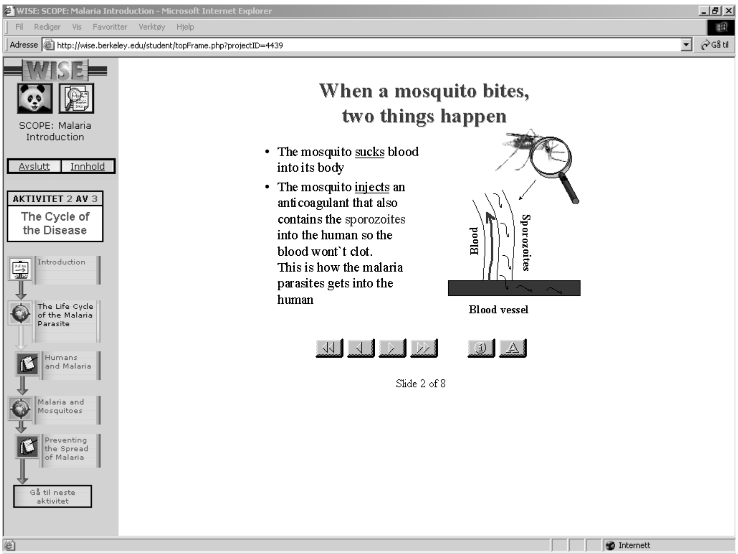

Figure 1.1: The WISE interface (Cycles of Malaria)

In all projects, we start with a sequence of motivational activities, also designed to help students and teachers map what is understood by students on the topic. The next sequence of activities is designed to present the actual science needed to understand the challenges placed into the scenario. Finally, the projects move into a phase where students work on some form of a final presentation of their role or task. Students may be asked to write newspaper articles for an on-line paper, or participate in a debate (both on and off-line) where they play different roles, or even create a product. This sequence of activities has the dual function of presenting the science in the core activity and then allowing students to use that science in a meaningful way.

1.2 Establishment of WISE in Norway

The project team, once moved to Norway, consisted of Doris Jorde at the University of Oslo and Alex Strømme at the Norwegian University of Science and Technology. Our initial efforts were to translate one project into Norwegian, at the same time, establish WISE in Norway as an official research program. Once funding through ITU was in place, we were able to add one technical/research associate to the project (Øystein Sørborg).

The first WISE project to be translated into Norwegian was called *Cycles of Malaria* in which students debate three different approaches for controlling Malaria worldwide: (a) developing of an effective pesticide that targets the anopheles mosquito, (b) developing a vaccine against this disease, and (c) creating social programs that reduce exposure to mosquitoes (e.g., through distribution of bed nets or community clean-ups). Students explore evidence relating to each control method, and debate alternative approaches. The curriculum provides three main activity areas:

1. **Malaria: A Global Problem** – students are introduced to Malaria as a global problem with an emphasis on where this is a problem in the world.
2. **The Cycle of the Disease** – students begin working with the complicated life cycle of the malaria organism, including the life cycle of mosquitoes. Control measures are introduced, locally and globally.

3. **Where Do We Break the Cycle?** – students work through activities which demonstrate three different approaches to control of Malaria: social measures to control the spread of mosquitoes, development of a vaccine against the malaria organism and development of pesticides.

To *make thinking visible*, the project includes animations and video of the mosquito and parasite lifecycles, as well as maps showing the worldwide incidence of Malaria. To make the debate *accessible to students*, we included the story of Kofi, an African child suffering from malaria and teachers often made connections to more personally-relevant diseases in North America, (e.g., HIV or Sickle Cell Anemia). The project *promotes lifelong learning* by encouraging students to compare scientific viewpoints, evaluate conflicting recommendations, and reflect on personal travel decisions. To *learn from others*, students discuss their ideas with peers and engage in class debates. Students learn about malaria through actual situations including comparisons between countries choosing to control use of DDT with those discontinuing use. Students compare infant mortality rates. They use the case to interpret the arguments in the legislation calling for a global ban of DDT. Similarly, information on vaccine research and development is examined since it is mainly conducted in developed countries where malaria is not a critical health threat. Students look at the economical and ethical arguments for why vaccine development should be a concern for all countries.

The *Cycles of Malaria* project was first developed in the United States as a curriculum for junior high school students. The project was translated into Norwegian and implemented for the first time in Norway in the fall of 1999. The Norwegian project included minor changes taking into account language when providing net based information. We successfully found links written in Norwegian to replace many of the English language links in the project. The US project concludes with an on-line debate about where the emphasis should be placed when considering plans to control the spread of malaria in the world. Our Norwegian classroom trials of the on-line debate were unsuccessful so that the Norwegian project concludes with an electronic newspaper activity in which students write articles on methods of control and create an online newspaper about malaria.

The development of Norwegian WISE programs promoted the start of international comparative research between the United States and Norway as teachers in different countries implemented the same programs (Cycles of Malaria and Wolves). The results of these studies (Jorde 2001; Slotta 2002; Jorde 2003) provided valuable information on how teachers use web-based curriculum materials in their science teaching. Our findings made us aware of the differences in school culture we experienced between the two countries. Differences in localization issues were related to the presence of a national curriculum in Norway as opposed to standards based curriculum based on assessment in the US. Whereas Norwegian teachers and students have experience with project work, schools in the US are much more rigid with regards to scheduling and defining clear roles for teachers and students. Norwegian schools had better equipment and more net connections that in the US schools. Common to both countries was the shared enthusiasm shown by students using WISE programs, expressing a continuing desire to have more net based curriculum materials in school.

1.3 From WISE to Viten

Once established as a research and development project with funding from ITU, the WISE team began looking critically at the technology provided by the WISE project. As our enthusiasm for developing WISE programs increased, so did our need to spread our wings and develop a software platform less reliant on WISE. Our implementation studies and in-service courses for teachers provided valuable information on the ease with which teachers were willing to use WISE in their own teaching. Together with teachers we began creating new ideas for the platform that would improve accessibility and also allow for creative solutions for curriculum development. As our enthusiasm grew, so did our frustrations with being so far away from the base operation in California.

We were eager to become more independent of the server and software in Berkeley so that we could control technological development in Norway. We made the important decision to begin the development of a new platform designed as a Learning Management Content System (LMCS) with interactivity between teachers and students. Other software platforms were evaluated at the time. However, since we were also a research project, we saw the advantages of designing and creating our own platform that could specifically accommodate our needs both present and future. This decision gave us the possibility of having direct access to the database and as well as being able to access data and create scripts for following statistics on program use.

Our new platform was called Viten with a web address http://viten.no.Viten is developed using free open sourced software. The server runs Linux Mandrake[5] with the Apache[6] web server and the database PostgreSQL[7]. All scripts are programmed in Perl[8]. Most of the content is made in Macromedia Flash[9] giving many more possibilities for interactivity, visualisation and simulations.

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5 Mandrake LinuxTM is a friendly Linux Operating System which specializes in ease-of-use for both servers and the home/office. It is freely available in many languages throughout the world. http://www.mandrakelinux.com/en

6 Apache has been the most popular web server on the Internet since April of 1996. The July 2003 Netcraft Web Server Survey found that 63% of the web sites on the Internet are using Apache, thus making it more widely used than all other web servers combined. http://httpd.apache.org

7 The PostgreSQL Global Development Group is a community of companies and people co-operating to drive the development of PostgreSQL, the worlds most advanced Open Source database software. http://www.postgresql.org

8 Perl is a stable, cross platform programming language. It is used for mission critical projects in the public and private sectors and is widely used to program web applications of all needs. http://www.perl.com

Compared to WISE, Viten is much easier for teachers to use (fewer clicks to register and arrive at programs), is less complicated to navigate within (teacher notes and communication tools all on same screen), is completely Norwegian, has a new layout and integrates new tools for curriculum development not found in WISE (including a net-based newspaper, quiz maker, argument maker, discussion forum, integrated teacher's guide). See Figures 1.2 and 1.3 for a comparison of WISE and Viten in Norway. Registration of students took about 20 minutes with WISE. Viten was able to reduce that to about 5 minutes. While our success with WISE was limited in Norway, Viten managed to accumulate 2000 registered teachers in the first year, and that without any marketing of the product.

Viten and WISE have developed in different directions, yet continue to share ideas for design and curriculum development. Now, in 2003, we are coming closer to technological solutions that will allow net based curriculum materials to be translated and shared by multiple software platforms, allowing Viten and WISE to converge. The WISE project has recently been awarded two new grants from the National Science Foundation; one to work with professional development related to use of web-based curriculum, the other to establish a center called TELS (Technology-Enhanced Learning in Science) together with 4 other universities in the US to conduct research on technology based curriculum. We look forward to continuing cooperation between the WISE project in the United States and the Viten project in Norway.

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9 Macromedia Flash MX is a tool used by over one million professionals to deliver the best user experiences on the web, increasing both revenue and customer satisfaction while lowering costs. The approachable environment includes powerful video, multimedia, and application development features, which allow designers and developers to create rich user interfaces, online advertising, e-learning courses and enterprise application front ends. http://www.macromedia.com/software/flash

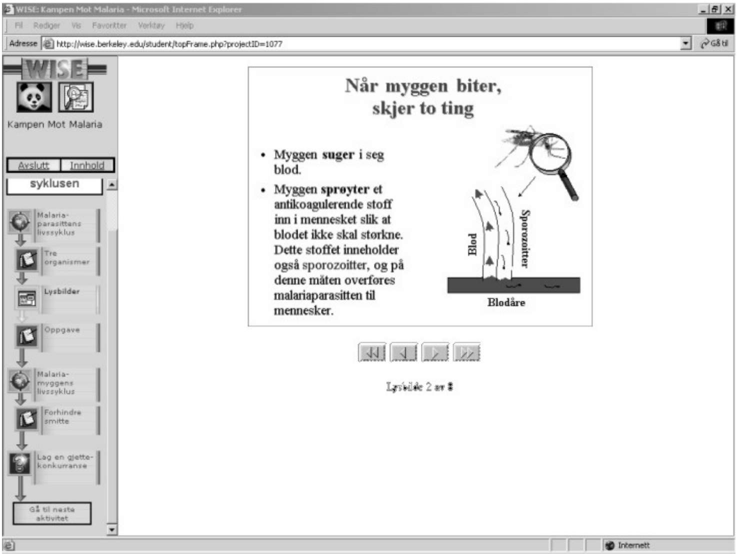

Figure 1.2: The WISE Norwegian environment (Kampen mot malaria)

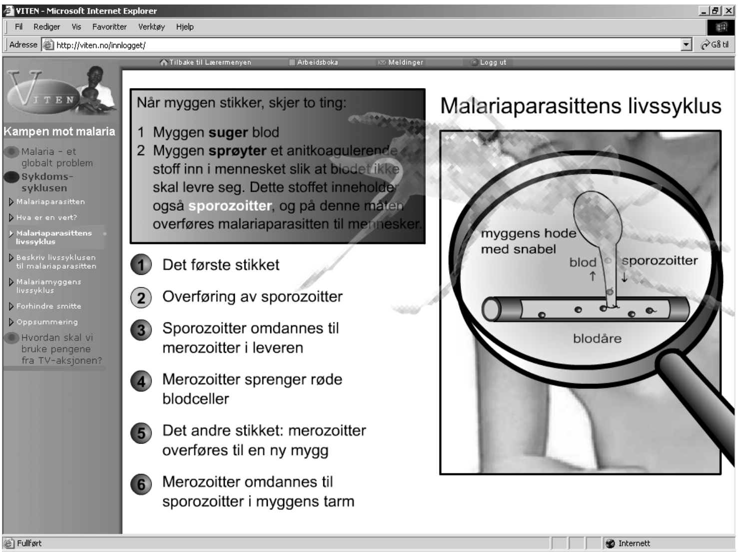

Figure 1.3: The Viten environment (Kampen mot malaria)   www.viten.no

Viten.no is now a recognized site for teachers using web-based science curriculum materials. The project has been able to expand its curriculum library with funding from parties interested in developing web-based school curriculum directed towards special interests. In addition to initial funding from ITU, Viten has been awarded funding from ROSA (Rovvilt og samfunn) to write about wolves and bears in Norway, from the Department of Education (Læringssenteret) to write a curriculum on gene technology and genetics, from the Department of Health to create an anti-smoking curriculum, The University of Oslo to write a curriculum in Math/Science (Sinus) and the Norwegian Research Council to write a curriculum on new energy sources. The Viten project has also worked closely with the PLUTO[10] project at NTNU in the creation of the radioactivity program. Together these funding sources have allowed us to increase our staff with the addition of Wenche Erlien, a former master degree student with Viten. Several additional students have been associated with the project on a short time basis to work on specific curriculum programs. Sonja M. Mork became a doctoral student with Viten in 2001 with funding made possible from ITU.

As of 2003 the Viten project consists of the following members:
Doris Jorde, Professor in Science Education, UiO
Alex Strømme, Associate Professor in Biology, NTNU
Øystein Sørborg, Researcher/technical design and development
Wenche Erlien, Researcher/curriculum design
Sonja M. Mork, doctoral student in Science Education, UiO

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10 PLUTO is the program for teacher education and technological-pedagogical reform (program for lærerutdanning og teknologisk-pedagogisk imstilling). Participating in the radioactive program from NTNU were Peter van Marion, Hilde Hov, Per Morten Kind, Øystein Sørborg, Wenche Erlien and Alex Strømme.

1.3.1
Viten – a short description

In the following pages, we present some screen shots to illustrate some of the functions found within the Viten software. We start in Figure 1.4 with an overview of the Viten interface. Figure 1.5 is an example of an activity page where students are asked to reflect by writing a note. The text is saved on the Viten server for later examination by either students or teachers. Figure 1.6 illustrates a page written for teachers. We provide extra hints, notes, ideas for experiments and other off-line activities on such pages. The teacher pages are only visible for teachers and more important, are accessible within the interface so that teachers always see student activities at the same time. In Figure 1.7 we demonstrate the integrated program editor. This tool is used by curriculum developers to create activity pages. In reality, teachers also have access to this tool. However, our research has shown us that teachers are not interested in working at this level of intricacy with the Viten program. Finally, in Figure 1.8 we demonstrate the teacher evaluation tool. Viten programs are filled with student activities that are answered and stored on the Viten server. At any time teachers may view student work and provide feedback by using this assessment tool.

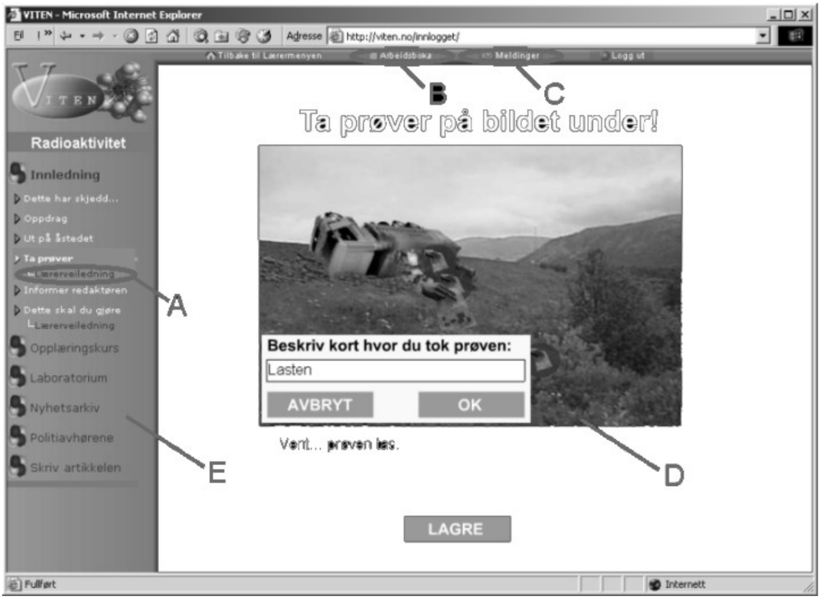


Figure 1.4: The Viten Interface. A:Teacher notes found only in the teacher version, B: Student workbook tool designed to save responses on the Viten server; C: Messages; D: Main window for learning objects (animations, texts, pictures, simulations, links); E: Navigation menu

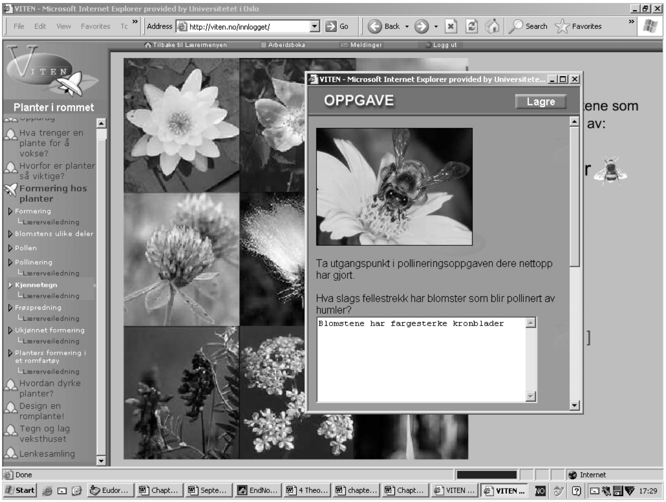


Figure 1.5: Example of note taking tool – responses are saved on the Viten server for teachers and their students to view.

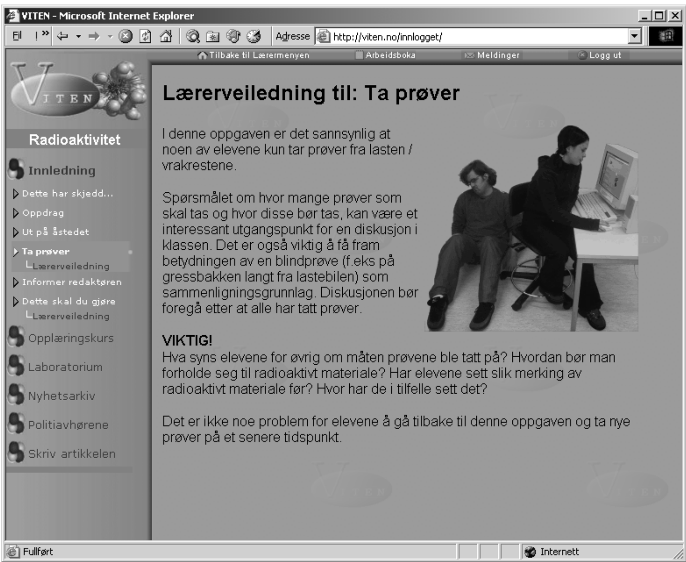


Figure 1.6: Illustration of a teacher page providing extra information and tips

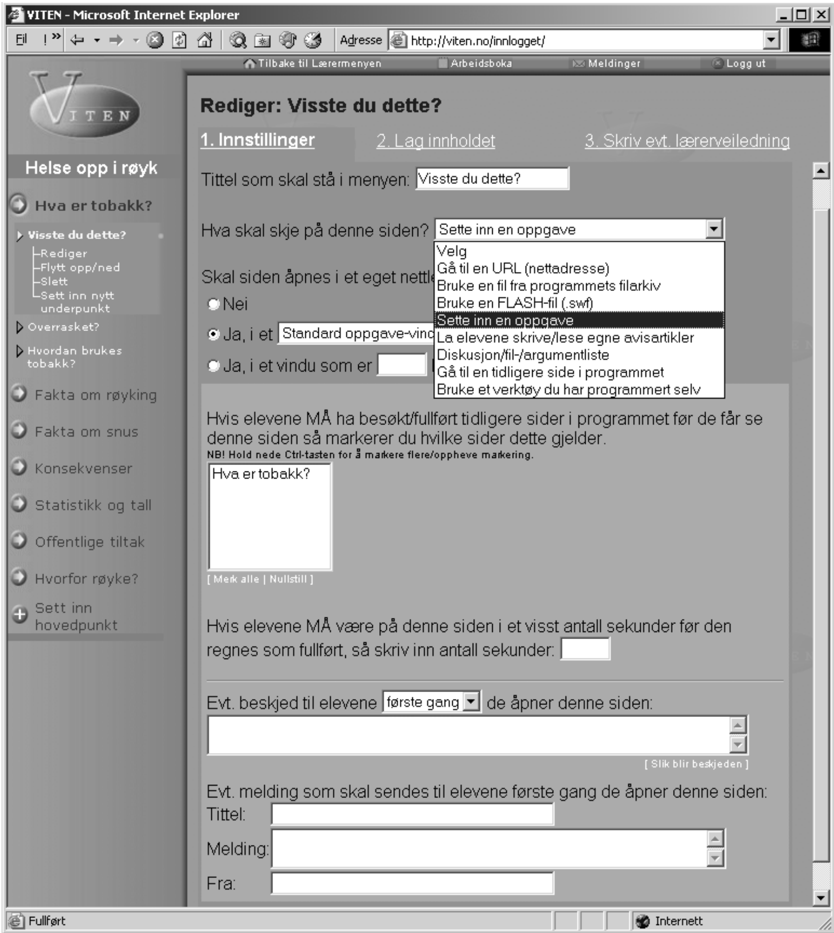


Figure 1.7: Integrated program editor

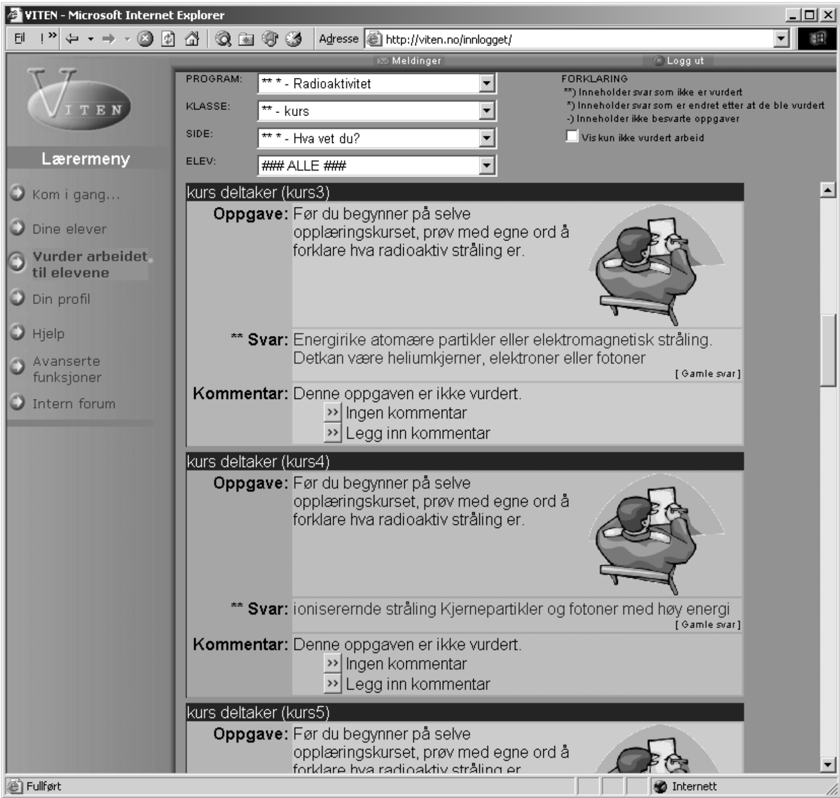


Figure 1.8: Teacher evaluation tool

Viten provides teachers the opportunity to:

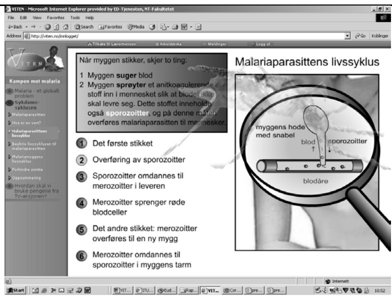
- Make comments for all student responses in the entire program (workbook) sorting them either by individual student (groups) or by tasks.
- Send the same comment to several students/tasks in the same operation.
- View, at any given time, those tasks for which comments have been made.
- View changes in student responses over time.

1.3.2 Current Viten program library

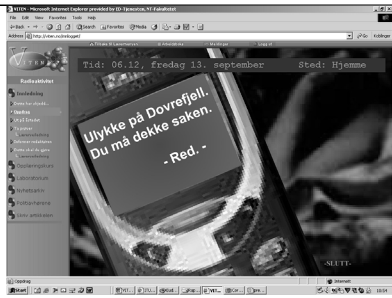
The current Viten library consists of 12 programs, available for teachers to access and use at any given time. The programs cover a range of topics in Science and Mathematics and a range of age groups from Junior Secondary to Senior Secondary school. As we reflect back on the last three years, we feel that we have been successful curriculum developers. As each new program becomes available, it contains new ideas and developments based on past experiences. We find ourselves in a constant learning and development process that incorporates our technological skills together with our ideas on what constitutes good science teaching. Classroom research, listening to students and teachers, keeping in tune with issues of science in our society are all factors that contribute to new Viten programs.

The reasons for choosing topics for the current Viten library vary. We created a program about wolves because the topic was a part of the public interest in Norway. The project on Bears soon followed. We choose to work with Radioactivity, Earth Processes and The Nature of Science programs since they are topics found in the science curriculum that tend to be difficult for most teachers to master. We choose to write about Gene Technology and Cloning because they represent controversial issues also of interest to the general public. The Malaria and Plants in Space projects were chosen so that we could work together with the WISE project on similar topics. We created the Sinus project as a way of connecting Mathematics to Physics in an authentic research area in Norway (i.e. underwater waves). The Hydrogen project is chosen both as an important science topic, but also as a means of creating new technological possibilities within Viten. The Smoking and Health project is a way of using Viten to help teachers work with decision making based on factual evidence.

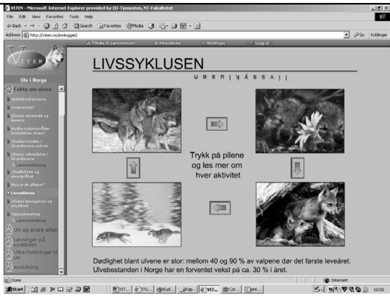
Two programs are in the development process at the current time. In the first project we are developing a program on Dinosaurs together with the Palaeontology Museum in Oslo. We are interested in using web-based materials to strengthen the museum – school connection. We are also working with climate researchers to develop a program incorporating a weather simulation tool into a Viten program on global weather.



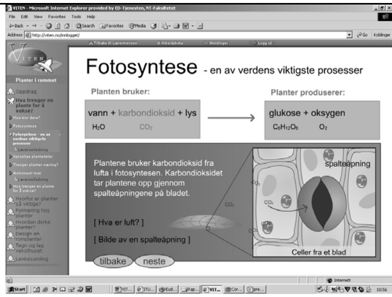
Cycles of Malaria (Kampen mot malaria) Grade level: 8-10
Description: Biology, controversy, debate, life cycles, global science



Radioactivity (Radioaktivitet)
Grade level: 9-11
Description: Physics, radioactivity, journalism, problem solving

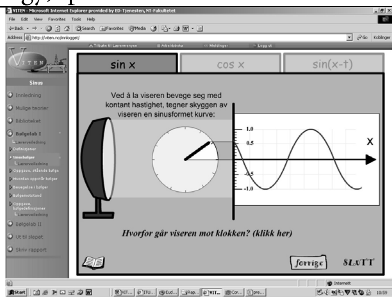


Wolves in Norway (Ulv i Norge)
Grade level: 8-12
Description: Biology, controversy, debate, ecology, animal behavior



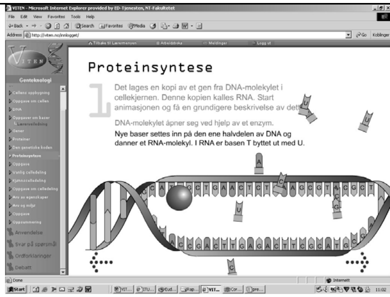
Plants in Space (Planter i rommet)
Grade level: 8-10
Description: Photosynthesis, respiration, plant reproduction, technology, space travel

Earth Processes (Norge blir til)
Grade level: 8-10
Description: Geology, land forms in Norway, history



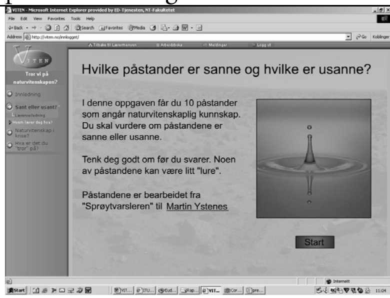
Sinus
Grade level: 11-12
Description: Mathematics, waves, underwater waves, history, problem solving

Bears (Bjørn)
Grade level: 8-10
Description: Biology, controversy, debate, ecology, animal behavior

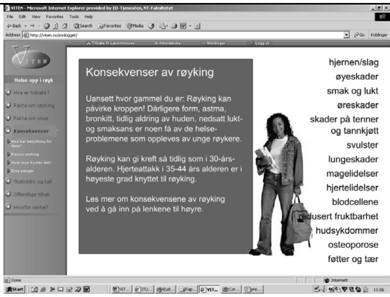


Gene Technology (Genteknologi)
Grade level: 9-12
Description: Genetic, controversy, problem solving

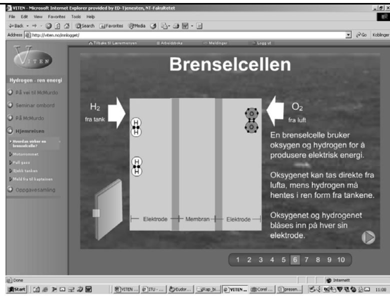
Cloning
Grade level:12-13
Description: Biology, gene technology, problem solving



The Nature of Science
Grade level: 11-13
Description: What is science? Anti-science



Smoking and health
(Helse opp i røyk)
Grade level: 8-10
Description: Biology, health, decision making



Hydrogen – a clean energy source
(Hydrogen – ren energi)
Grade level: 11-13
Description: Energy sources, fuel cell, problem solving

Figure 1.9: The Current Viten Library

2
The role of technology in science teaching

2.1
Science Teaching

Within the science education community there is consensus that science should be a part of what we define as general education. Scientific literacy is a term used to describe the goals citizens should acquire of basic knowledge about what science is and how science works. The dimensions necessary for public understanding of science would include understanding some aspects of science content, understanding the scientific approach to inquiry and understanding science as a social process (Sjøberg 1998). These three dimensions of science are closely linked together and often difficult to distinguish from each other.

In almost all countries science is included as a main component of the curriculum together with mathematics and language, all of which form the basis of general education. The arguments for including science in a basic education and thus creating a scientifically "literate" society include (Driver et al. 1996; Sjøberg 1998):

- The economic argument – preparation for work in areas of science and technology
- The utilitarian argument – being able to cope with science in daily life situations
- The democratic argument – preparation for participation in a democratic society, including decision making about controversial issues with a science dimension
- The cultural argument – that science is a part of our cultural heritage and therefore an important part of general knowledge

In Europe, where enrolments in the sciences are declining, we are concerned with issues of recruitment. Educators seem to agree that countries can not start early enough in presenting motivating and engaging science programs in schools for all children such that an ample number of students will keep their options open for advanced studies in these areas. And certainly one can not argue with the need for an educated society for participation in the democratic decision making process. Citizens will not only need to know some science, they will also need to know how science operates and where to access reliable information they can trust. The European Community has taken up the issues of scientific literacy in their statement on educational objectives from 2001:

> As we are moving into a knowledge society, we will need to increase the general levels of scientific culture within society. Expertise in science and technology is increasingly called upon to contribute to public debate, decision making and legislation. The citizen needs to have a basic understanding of mathematics and science if they are to understand the issues and make informed – if not even technical – choices. (EU 2001)

Most western countries are dealing with a state of decline of those students choosing to take science courses and later to study science at the advanced level. In efforts to alleviate this problem the science education community has been forced to look critically at its own practice. Certainly we agree that schools play a role in obtaining the educational objectives described above. At the same time, we know that educational systems are concerned with the quality of science teaching and learning. What are the reasons as to why school science seems to be in a state of decline with respect to recruitment and interest? Why are fewer students generally and girls especially, choosing to move away from science? Is the science curriculum the problem or could it be the delivery by teachers and textbooks? Does our present youth culture find studies in science to be uninteresting and non-relevant?

Among responses to many of the problems facing the teaching of science, we also find attempts to improve the situation. Projects promoting the Public Understanding of Science (PUS), the Nature of Science (NOS) and Scientific

Literacy (SL) have played an important role in our understanding of the content of school science. Other projects, including Science Technology and Society (STS) and Science in Society, promote the integration of science topics into a social context. The latest trend in science curriculum development is the introduction of Information, Communication Technologies (ICT). ICT may indeed embrace the notions of many of the previous curriculum emphases. What differs when we use ICT are the presentation methods and the new opportunities available for the delivery of science information to the learning environment.

2.2
ICT in the Science Curriculum

The Norwegian government has a long tradition of supporting the use of ICT in schools (KUF 1996; KUF 1996; KUF 2000). Curriculum guidelines have emphasized the use of ICT in all subjects, teachers have been given the opportunity to take courses in the use of ICT in teaching and funding has been available for schools to purchase computers and have Internet access. These ambitious plans have placed Norway as an international leader in the number of computers available to students (Quale 2000). At the same time we seem to be lagging behind on what might be called “modern” technological uses of information technology in teaching.

Emphasis in the area of information technology continues as recent statements and documents produced by the Department of Education have suggested that digital literacy (digital kompetanse) be added to the list of basic skills (also to include reading, writing, numeracy and English) in the Norwegian education system (Høykom 2003; Søgnen 2003). It is further suggested that these basic competencies be addressed in all subjects within the national curriculum so that implementation is carried out across the curriculum. As science educators also interested in the use of ICT in teaching and learning science, we welcome the emphasis placed on ICT (Strømme 2002).

When we integrate the use of ICT into the science classroom, we are introducing possibilities that never before existed in how to teach and learn science. Through the use of the Internet, we are able to provide authentic data for students allowing them the possibility to make connections between basic knowledge and applications of that knowledge. We are able to create simulations and animations that make the unobservable observable as we can move inside cells and visualize the processes of photosynthesis and respiration as examples. Scientific concepts are presented in new dimensions making what often are difficult ideas in science more accessible to students. ICT allows us to help students access, evaluate and make use of information that connects science to society and decision making processes. ICT allows science teachers the opportunity to introduce their students to up-to-date studies in science that are often outside the possibilities found in traditional teaching materials. Without question, the use of ICT in science teaching means that students are allowed to explore and ask questions about science rather than be passive recipients of information (Jorde 2002, Jorde 2003).

ICT is certainly not the only way to teach science since we will continue to observe real phenomena in nature, read books and conduct experiments. ICT does, however, enhance the way we teach science by providing new possibilities for teaching difficult concepts and ideas. Complex systems may now be simulated, experiments involving expensive equipment may be animated, empirical data may be collected with handheld devices, controversial topics may be discussed with experts and people outside the immediate classroom and information may be found linking school science to authentic science research.

According to the National Research Council in the US (Council 2000), there are five ways that technology can be used to help meet the challenges of establishing effective learning environments:

- Bring real-world problems into the classroom through the use of videos, demonstrations, simulations, and Internet connections to concrete data and working scientists.

- Providing "scaffolding" support to augment what learners can do and reason about on their part to understanding. Scaffolding allows learners to participate in complex cognitive performances, such as scientific visualization and model-based learning, that is more difficult or impossible without technical support.
- Increasing opportunities for learners to receive feedback from software tutors, teachers, and peers; to engage in reflection on their own learning processes; and to receive guidance toward progressive revisions that improve their learning and reasoning.
- Building local and global communities of teachers, administrators, students, parents and other interested learners.
- Expanding opportunities for teachers' learning.

As new technologies become available, science educators and curriculum developers need to be aware of the possibilities they afford for enhancing science teaching and learning.

2.2.1 ICT connects science teaching to actual research

Large research institutions such as NASA, CERN, and ESA etc; are able to enter the science classroom via the Internet, providing opportunities for students to obtain first hand information about scientific research. Visiting the sites provided by the World Health Organization (WHO) and The Center for Disease Control (CDC) allows us to integrate global health issues into lessons about health and sickness. There is no longer a need to talk about outdated textbooks when ICT is available to keep science teaching and learning up-to-date. Our challenges are to help students access reliable resources, help them with making sense of information and to understand the difference between science and anti-science.

2.2.2 Scientific literacy linked to computer literacy leads to an informed public

The knowledge base for life long learning is quickly becoming the Internet. If we are interested in providing citizens with the science they need to participate in a democratic society, we are obliged to also help students navigate this huge data base of information. Knowing where to look for information and who to believe is perhaps more important now then ever before since there is no control over information flow.

Young people need to be introduced to the many complex socio-scientific issues requiring information in today's society so that they are equipped to deal with these issues in a more meaningful way. Genetically modified organisms, energy sources, global warming, ecological issues (including the presence of wolves in Norway) are all issues related to public policy and decision making in a democratic society. Science is at the base of these topics but that does not necessarily mean that there is consensus in the scientific community about solutions to the actions society should or could take. Science teachers and curriculum developers need to address the issues of the nature of science so that students understand how science works, who they will choose to believe and where they will look for reliable information on issues.

By connecting scientific literacy to computer literacy, we empower students with the tools necessary to engage in life long learning for responsible decision making.

2.2.3 The changing role of the learner

When ICT is used in the classroom, the source of information moves from the textbook and/or the teacher into the computer and the Internet. The pedagogical flow of the classroom moves away from the teacher-student dyad where the teacher is in control, into a student-student dyad where reflective discussion places the responsibility for learning with the student(s). Using appropriately developed software tools, we are able to engage students in reflection and peer discussion thus allowing increased use of discourse in the science classroom. Language and science are very much associated in the learning process as students are introduced to new ideas and then allowed to talk about them to internalize their meanings.

As more and more homes and schools are equipped with computers and Internet connections, students are growing up in a world where information is always accessible. In other words, ICT is quickly becoming a part of the youth culture. Educators and curriculum developers can not neglect the youth culture since this will mean further separation between school science and the world students live in. Our challenge is to provide pedagogically sound Internet based curriculum materials that are also in tune with the technological advances available.

2.2.4 The changing role of the teacher

There is no question that the role of the teacher changes when ICT is introduced into the classroom. We are still exploring unknown territory when we talk about the modern classroom and new strategies for teaching and learning while using ICT. And though the role of the teacher will change in these new classroom environments, this does not at all mean that the role of the teacher will become less important.

The teacher will become the hub of many divergent activities going on within a science classroom where students are asking questions not necessarily directed towards the teacher, rather to each other or someone not even present. The teacher's role will be to help students understand scientific concepts through scaffolded discussion and presentation related to information they have accessed either through the Internet or other available resources. The emerging use of Learning Management Systems (LMS) as a means of organizing schools will also open the door to new roles for teachers as they learn to organize the content of courses within a web-based methodology of instruction. The opportunities to provide electronic feedback to students as well as engaging in electronic discussions will place both the teacher and student in new roles and relationships.

The availability of Internet based pedagogical tools is in its infancy. Even though teachers become more adapt at using information technology, this will not necessarily mean that they will increase the use of technology if they are not convinced that new methods are improvements over existing teaching methods. As curriculum developers, this is an important point to keep in mind. At the same time, we need to concentrate efforts on updating teachers and school leaders with in-service technology courses so that they are able to assess the possibilities afforded by ICT. If we are to succeed with the implementation of new pedagogies that include the use of ICT in learning environments, it is essential that all of the actors in the school system (teachers, administrators and students) have equal access and opportunities to experience the benefits of information technology.

3
Theoretical perspectives on Viten

Sonja M. Mork

3.1
Introduction

The main aim for all Viten programs is that students should learn about the processes and products of science. 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).

Viten is a research and development project and draws upon experiences from research. The Viten project leader, Professor Doris Jorde, has many years of experience from classroom research both in Norwegian- and international projects. In addition Viten also finds it important to draw on information about what constitutes positive learning gains from other science education research projects, and classroom research in general. By using a combination of positive experiences from different research projects when developing the Viten teaching programs, one could say that a Viten framework for science teaching with a basis in a social constructivist view of learning is established. A brief presentation of the learning perspectives central in the Viten project and how learning is connected to information technology is given in the first part of the chapter followed by a description of important principles Viten draws upon.

3.2 Learning with information technology

There has been a turn in focus from viewing learning as cognitive processes in the individual to viewing learning as a process going on in social contexts (Solomon 1994; Scott 1998; Säljö 1999). A view of learning focusing on social processes has its origin in the Russian psychologist Lev S. Vygotsky's ideas (1978) about human development. In this tradition continuity between thought and language is important. Language is seen as the most unique part in development of knowledge, and the mastery of communicative and intellectual tools is a central in of the learning process. The process where the learner reorganizes and reconstructs talk and activities from the social arena is called internalisation (Vygotsky 1978). The process of 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 come to a personal understanding of ideas encountered at the social plane. (Leontiev 1981; von Glaserfield 1999; Leach and Scott in press). In this way you could say that theories originating from Vygotsky's work share common ground with a constructivist perspective in recognizing that the learner cannot be a passive receiver of knowledge and information (Mortimer and Scott 2000).

The introduction of technologies into human activities, and the use of such resources for learning and for the mastery of complex activities is nothing new (Säljö 1999). Throughout history people have developed technologies to help them solve intellectual and practical problems e.g. introduction of the technologies of writing was a revolutionary information technology in its time and the ways in which humans learn – i.e. retain, reproduce and produce information, knowledge and skills – changed dramatically when writing became used as a resource for communicating in social life (ibid). So when we follow the development of technology through history, it is not just the tools that change. The tools that are available at any time also influence our thinking and learning. It is therefore exciting to study how information technology as a tool influences the way people learns.

Students cannot learn "science" on their own without guidance from other persons or tools. Vygotsky (1978) introduced the term zone of proximal development (ZPD), and meant that this zone can be understood as the distance between what an individual can manage on there own, without help from others, and what the individual can manage with support from other and more competent persons. Focus has centered mainly on the importance of the teachers role in scaffolding students in the learning process. But this 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 to be scaffolds giving students various kinds of feedback and challenges in their learning process (Mork in prep).

According to Doris Jorde (2002; 2003), information technology provides new possibilities for teaching difficult concepts and ideas. Complex systems can now be simulated, experiments involving expensive equipment may be animated and controversial topics may be discussed with experts and people outside the immediate classroom. Information may be found linking school science to authentic science research. Working at the computers does not automatically produce learning and understanding, but the technology provides new opportunities for manipulating models and concepts in a manner that may facilitate learning. Roger Säljö (1999) states that creation of knowledge is essentially a matter of learning to argue, and no technology will ever replace the need for learners to participation in ongoing conversations with partners sharing the same interests and commitments. Technology should not be seen as replacing such communication, but rather as providing a resource for supporting it.

In a review of studies investigating the effectiveness of computers as learning tools, Roschelle et al. (2000) claims that technology may enhance the way students learn by supporting the following four fundamental characteristics of learning; active engagement, participation in groups, frequent interaction and feedback and finally, connections to real-world contexts. Roschelle et al. further says 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 programs.

While learning has traditionally been associated with remembering information, a more central question now is: *What is the best way of transforming information found in the computer into knowledge within the group or individual?* There is a significant difference between information and knowledge. According to Salomon (2000), information may be transferred, while knowledge must be constructed as a web of meaningful connections. Salomon claims that the process of transforming information into knowledge is effort demanding and purposeful, and requires tutelage and a community of learners. Viten programs guide students in organising information and, through different activities, challenge them to reflect upon and use this information in a context (see Figure 3.1). In this way Viten programs together with teachers, are scaffolding the students in the process of transforming information into knowledge.

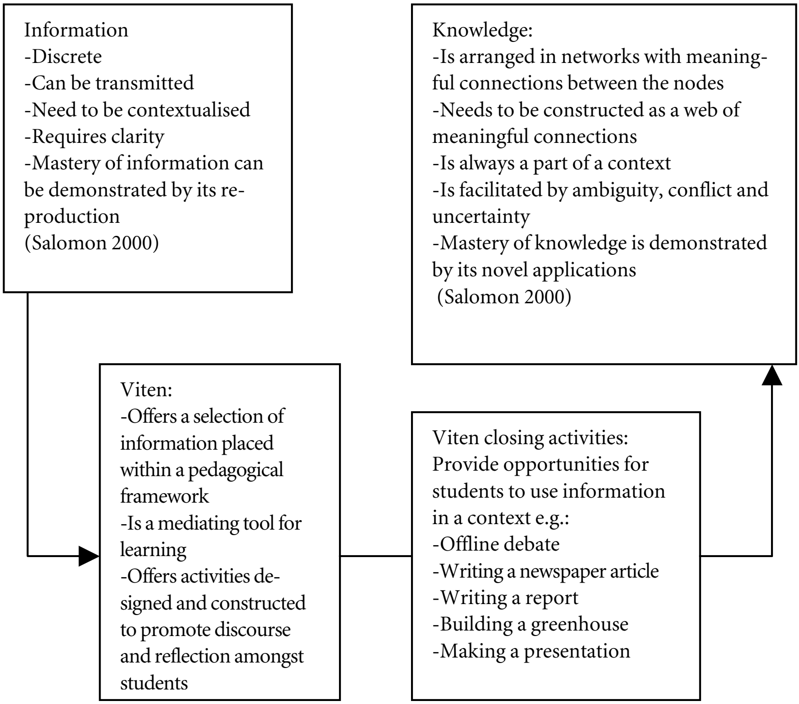


Figure 3.1: Viten model for the transformation of information into knowledge

3.3 Important principles in the Viten framework

The Viten framework draws upon theories and research about the importance of teaching science in a context, the social construction of knowledge, the importance of talking science, use of different learning strategies and the importance of communicating with the language and symbols of the youth culture.

3.3.1 Teaching science in a context

Modern western societies are becoming more and more advanced due to exponential growth in many fields, such as technology and economics. Scientific and technological research has played an important role in this development. This growth has had both positive and negative impacts on nature and humans. Students will increasingly need skills for dealing with science related issues as they prepare to participate in the democratic process. Scientific issues taught in schools today may seem unavailable to some students, and many students have trouble seeing the relevance of knowledge about such issues. A possible reason for this may be that science teaching traditionally has focused on science as facts and unquestionable knowledge. Kolstø (2003) says that for the time being school science still seems to build on a picture of science as academic science after a model from the last centuries, and with a naïve positivistic view of knowledge. In an evaluation of the Norwegian national curriculum Tveita et al. (2003) reported that science and environmental studies are still taught very theoretical in spite of the objectives in the curriculum about more student activity. Many scientific theories seem to be presented relatively isolated from the surrounding world and contribute to problems for students transforming this knowledge to their own everyday life. 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.

Teaching science non-contextually is not just a Norwegian phenomena; within the international science education community there has been a focus on these problems for decades (Solomon and Aikenhead 1994). Science educators seem to agree that relevant real life contexts are important factors when teaching for scientific literacy. Knowledge about how students deal with such issues is of relevance when designing curricula and teaching models aimed at scientific literacy (Jenkins 1994; Driver et al. 1996; Kallerud and

Sjøberg 1997; Millar and Osborne 1998; Aikenhead 2000; Driver et al. 2000; Kolstø 2001). According to John Ziman (1994), science, technology and society teaching (STS) appreciates the diversity in science and seeks to increase, complement and expand it. He further argues that the fundamental weakness in traditional science teaching is not what is taught about the world, but what is not taught.

There is a need to look at different approaches to science teaching if we are to take these issues seriously. Student preconceptions need to be taken into consideration and "school knowledge" needs to be more closely integrated with actual issues in the everyday life of students. Viten programs share many of the characteristics of STS teaching; i.e. conveying the image of socially constructed knowledge. Its approach is student-oriented and emphasizes the basic facts, skills, and concepts of traditional science, but does so by integrating the science content into social and technological contexts meaningful to students. According to Aikenhead (1994), good STS teaching is relevant, challenging, realistic, rigorous, and aims to prepare future scientists and citizens alike to participate in a society increasingly shaped by research and development involving science and technology.

In a review of research on effects of such courses, Aikenhead (1994) concluded that STS instruction can make an appreciable difference to student understanding of STS content, thinking skills, and attitude towards science. Although students' understanding and attitudes may be resistant to change, the high degree of interest and enthusiasm that students express for STS instruction indicates that future developments toward such instruction will receive encouragingly positive reaction from most students. However, in spite of these encouraging results, it does not seem like these experiences have changed the approaches to science teaching in practice. The challenge is therefore to continue to develop teaching approaches that relate scientific content to real world contexts, and to find was to distribute and implement them. In this way we will be able to contribute to a science education more relevant for students.

The time has therefore come to mix some of the good principles and experiences from STS teaching with the major possibilities that lie in the use of new technologies like the Internet. The new information technologies represent unique possibilities for making science teaching more relevant for students' everyday life. The Viten project is exploring and exploiting the advantages of information technology for connecting science teaching to students' everyday life. Viten programs are connected to real-world contexts and are often set up as cases with a mission for the students to fulfil. In this way Viten programs, according to SKI-principle no 1, are making science accessible for students. The following example from the radioactivity program is used to illustrate this point:

The teaching program about radioactivity has its origin in traditional theory about radioactivity, but the theory is put into a context relevant for students' everyday life. A case is developed where students are given roles as journalists. Their mission is to cover an explosive fire in a truck accident in the mountain area Dovre. Traces of radioactive substances are found at the scene of the accident; a finding that the reporter finds necessary to investigate further. To solve the task, students need to collect information about radioactivity, do measurements and analyses in a virtual laboratory, and learn how to write a newspaper article with scientific information.

The reason for choosing this approach is the aim of connecting scientific information that may seem unavailable to many students to situations that might happen in their own everyday life. At the same time one wants to show students that radiation is a debated theme in our own society and that possessing knowledge about the issue is important if one is to be an informed citizen in a democratic society. The mountain area Dovre was chosen as the scene of the accident because radioactive substances from the Tsjernobyl accident in 1986 are still found in the environment. Students thereby learn something about the consequences such effluents might have on the environment, geographical range, and effects over time and half-life. The students also find the radioactive substance americium in their samples; a substance that comes from smoke alarms found in the cargo of the truck in the accident. The objective is to show students that some types of radioactive substances in small amounts can be useful. Hopefully this can contribute to a more nuanced understanding of radiation in addition to that students learn how radioactive substances can be identified based on measurements of radiation activity (Mork in prep.).

3.3.2 The social construction of knowledge

We recognize that learning has its origin in social contexts and the importance of the social construction of knowledge in the initial stages before the individual can come to an personal interpretation and understanding. The concept of the ZPD, (Vygostky 1978) was introduced as an alternative approach to measure students learning gains, but it also illustrates how individuals draw on the social surroundings and tools in the learning process. The ZPD does not just account for what an individual can manage on its own, but also what the individual can manage by guidance of more experienced persons or tools. So how can we help students to reach goals that they could not achieve on their own? In Viten we try to account for this in three ways; first by aiming to construct the content of Viten programs (tasks, activities, texts and multimedia components) in such a way that they serve as scaffolds for students in the learning process.

Secondly, by letting the students work in pairs and with tasks constructed in such a way that it is advantageous to cooperate to solve them, we hope to promote social interaction and discussions among the students while they are working with the Viten programs. This is an example of how students learn from each other. In a review of research in cognition and learning, Greeno et al. (1996) claims that learning research has shown that students learn best by actively “constructing” knowledge from a combination of experience, interpretation, and structured interactions with peers and teachers.

The third way in which Viten supports the student learning process is by the social construction of knowledge through the closing activities in the different Viten programs. It is important to emphasize that a Viten program is not completed when the work with the online knowledge base is finished. Each Viten program has a closing activity in which students use the information from the curriculum in a special context; e.g. offline debates, write a newspaper article, build a greenhouse and so on. The closing activities are often offline activities, where the students are expected to process information they have collected from the knowledge base part of the Viten program. In Figure 3.2 students have used information learned from the Plants in Space program to construct a green house with ideal conditions for growing plants in a space ship on a journey to Mars. During this process they discuss how they are going to exploit information provided in the online part of the plant program to build an efficient green house. This is an example of making thinking visible.

Figure 3.2: Student pairs building a green house, and finished products.

After building the green houses all student pairs presented their model and gave arguments for why they chose to build it the way they did. The class discussed advantages and disadvantages of each model, a sequence that is a good example of social construction of knowledge. Excerpt 1 is an example of a student pair's argumentation for their model. In the excerpt the students demonstrate that they have learned that there is no force of gravity in space; a fact taken into consideration when constructing their green house. They have also learned that plants need solar energy, water and some nutrients, which normally are dissolved in water to grow. What we miss from this sequence of argumentation is the fact that the plants need carbon dioxide, and the mention of the crucial process of photosynthesis. When looking in the students' electronic workbooks we find solid reasoning about how to supply the plant with carbon dioxide and why they want to use a plant where the roots are the part to eat.

Excerpt 1: Shows an example of how one student pair argues for their design construction of a green house.

English
We chose the plant to grow in air, since in a space ship there is limited access to water, and the plant needs a great deal of water both to grow in soil and water. If the plant grows in water, the water would need to be changed often, and new and fresh water would need to be supplied to the plant. That is why we chose air.
We also chose air because it is easier to take out the roots, which are to be eaten. In soil you must dig to get hold of the roots, and in water you must take out the water first. That can be a great deal of mess, since there is no force of gravity in space.
Since we chose air, the plant needs a supply of water and nutrients to

Norwegian
Vi valgte at planten skulle vokse i luft, fordi i et romfartøy er det begrenset tilgang på vann, og planten trenger en god del vann både for å vokse i jord og vann. Hvis planten skulle vokst I vann, måtte vannet ofte skiftes ut og nytt og rent vann måtte tilføres planten. Derfor valgte vi luft.
Vi valgte luft også fordi det er lettere å ta ut rotknollene som skal spises. I jord må du grave for å få tak i rotknollene og i vann må du ta ut vannet først. Det kan bli en god del søl fordi det ikke er tyngdekraft i verdensrommet.
Siden vi valgte luft, trenger planten tilførsel av vann og næringssalter for å overleve. Derfor lagde vi en "sprutemaskin" som tilfører planten næringssal-

survive. Therefore we made a "splash machine" which supplies the plant with nutrients and water. From the "splash machine" there is a tube to a container that contains these substances.
We made a kind of "sun", because the plant needs solar energy to grow. Then it will grow in the direction towards the sun.
In the greenhouse we attached a plate to separate the leaves and the roots. This is because we don't want the roots to grow parallel to the stalk and the leaves and shade the "sun". In space there is no force of gravity either.
We made an opening in the bottom of the green house, with a door, so that we can easily catch the roots that we are going to eat.

ter og vann. Fra "sprutemaskinen" går det et rør til en beholder som inneholder disse stoffene.

Vi laget en slags "sol" for planten trenger solenergi for å vokse. Da vokser den retningen sola står.
I veksthuset festet vi en plate for å holde bladene og røttene fra hverandre. Dette gjør vi for at ikke røttene skal vokse oppover stilken og bladene og dermed stege for "sola". Det er heller ikke noe tyngdekraft i verdensrommet.
Vi laget en åpening nede i veksthuset med en "dør" foran så vi lett kan få ut rotknollene vi skal spise.

During work with the closing activity we expected students to revisit pages to revise or increase the level of precision of their knowledge. This is perhaps the most important part in the learning process. The Norwegian results (Lie et al. 2001) from PISA show that Norwegian students score poorly regarding use of control strategies as a part of their own learning process. There are positive correlations between the use of such strategies and learning output (Lie et al. 2001).

3.3.3 Talking science

We agree with Duschl and Osborne (2002) in that students must have an opportunity to engage in activities which require them to use the language and reasoning of science with their fellow students and teachers - that is to engage in the construction and evaluation of scientific argument. Lemke (1990) says that it is when we have to put words together and make sense, when we have to formulate questions, argue reason, and generalize, that we learn the thematics of talking science. In the wolf teaching program the students are given the opportunity to use their language and practice the construction of arguments both by working together in pairs, but also by engaging in a classroom debate. Excerpt 2 shows examples of student argumentation in a classroom debate which was conducted as a role play (Mork and Jorde 2003).

Excerpt 2: F-students are arguing against wolves, and N-students are arguing for wolves.

English:
1. Student F3: Besides, we in the Norwegian Hunting and Fishing Association have noticed a considerable decrease in the moose, parallel with the increase in wolves. Moose we could have hunted and sold. Few moose means higher prices, and nobody wants that. This is threatening to our business.
2. Teacher: But don't you in the Association for Nature Protection have any understanding for these hunters that really have problems?

Norwegian:
Student F3: Dessuten har vi i Norges Jeger og Fiskeforening merket en betydelig nedgang på elg, parallelt med økning i ulv. Elg som vi kunne ha skutt og solgt. Lite elg betyr høyere priser og det vil ingen ha. Dette er farlig for vår busniss.
Lærer: Men har ikke dere i Naturvernforbundet noen forståelse for disse jegerne som virkelig har problemer. Det blir mindre elg å skyte og ulven tar bikkjene deres...
Student N4: For det første så er det

There are fewer moose to hunt, and wolves kill their dogs…
3. Student N4: First, 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.
4. Teacher: But it is a fact that there has been an increase in the wolf population the last years?
5. Student N4: Yes, of course, but they must definitively have permission to kill moose. That's their diet isn't it? Just like other predators they must catch the preys they need to survive.

veldig lite ulv enda, så jeg skjønner ikke at dere kunne ha merket nedgang i elg. Det er jo altfor lite ulv i Norge.
Lærer: Men det er jo en kjensgjerning at det har vært en økning i ulvebestanden de siste årene.
Student N4: Ja, selvfølgelig, men de må jo få lov til å ta elg de også. Det er jo det de lever av ikke sant. Akkurat som et annet rovdyr må jo ta det viltet de skal ha.

Excerpt 2 starts with student F3 in turn 1 claiming that there has been a reduction in the Norwegian moose population because of wolves. This information is not correct, but we classify the argument as biological, since the student demonstrates knowledge about population ecology in form of predator-prey relations and how they influence each other. Such information about predator-prey relations is embedded in the wolf curriculum. Student F3 also indirectly shows that he is familiar with the fact that moose and other species in the deer family are the main food resource of wolves. It is also interesting to note that at the end of turn 1 student F3 uses the biological information as backing for an economic argument.

Turn 2 shows an example of the active role of the teacher in the debate. Here the teacher repeats the argumentation of student F3 and transforms it into a question, which she addresses to the students representing the Association for Nature Protection.

In his answer student N4 also uses biological argumentation when he in turn 3 correctly points to the fact that the Norwegian wolf population, which at present consists of about 20-30 individuals, still is far too low to influence the large Norwegian moose population (about 38 000 individuals are shot by hunters every year).

In turn 4 the teacher challenges student N4 on the question of population size, and student N4 goes on say that he is aware of the increase in the wolf population, but he stresses that moose is an important part of the diet of wolves. Like student 3 he demonstrates knowledge about population ecology and the relationship between predators and preys and the laws of nature.

As we can see from excerpt 2, the classroom debate becomes a kind of community of learners where students and the teacher are constructing knowledge together, a process that Mercer (1995) would have called the guided construction of knowledge. This is also in line with Vygotsky's (1978) perspective on development and learning, which states that learning originates in social situations. Newton et al. (1999) is claiming that talking offers an opportunity for conjecture, argument and challenge. In talking, learners will articulate reasons for supporting particular conceptual understandings and attempt to justify their views. Others will challenge, express doubts and present alternatives, so that a clearer conceptual understanding will emerge. However, before students are able to use their language and engage in such argumentation and debates, they need to have some information about the topic so that they can use evidence as foundation for their arguments. In the wolf program this information is provided in the computer based part of the Viten program.

3.3.4 Learning strategies

We know that students have many different ways in which to acquire knowledge and that learning might be viewed as an increase in the student's repertoire of strategies for transforming information into knowledge. Ausubel et al. (1978) operates with two dimensions for learning strategies; a continuum from meaningful learning to rote learning, and a continuum from discovery learning to reception learning. Results from the Programme for International Student Assessment (PISA) show that students report using both memorisation and elaboration strategies in assimilation of new knowledge. In addition co-operative and competitive learning strategies also have their place in students' effective learning, not as alternative, but complementary strategies (OECD 2001). However, the Norwegian national report from PISA shows that contrary to other countries, Norwegian students seem to have a small repertoire of learning strategies (Lie et al. 2001). This is problematic for Norwegian schools that give students a lot of responsibility for their own learning process, and focus on the lifelong learning perspective.

Information technology is a tool that has a major potential to meet these challenges. The design and construction of Viten programs provides tools that try to meet the students half way in the process of transforming information into knowledge. Viten programs are constructed as a knowledgebase and designed in a structure that contains both information and a wide spectre of various types of activities closely related to this information (see Table 1), enabling students to use a wide repertoire of learning strategies and take control over their own learning process.

Table 1: Combination of types of learning strategies referred by PISA, Knain (2002), Ausubel et al. (1978), and examples of activities stimulating these in Viten programs.

Learning strategies	Examples from Viten programs
Control strategies	Drag and drop activities about the lifecycle of the parasite in the malaria program. Drag and drop activity about photosynthesis in the plant program. Quiz in the radioactivity program to sum up the training course about radiation. When using information to build a green hose for plants in a space ship.
Elaboration	Use elaborating strategies to be able to solve tasks that require reflection in all the Viten programs. When writing a newspaper article in the radioactivity program. When evaluating strategies to combat malaria in the malaria program. When evaluating argumentation in newspaper articles about wolves.
Discovery learning	Take samples of radioactive material and analyse them in the virtual lab in the radioactivity program. Use knowledge and build a green house for growing plants in a space ship in the plant program. Solve the mission in the sinus program
Co-operative strategies	Cooperate to solve all the tasks in the various Viten programs. Use knowledge and build a green house for growing plants in a space ship in the plant program. Cooperate to prepare for the offline debate in the wolf program. Cooperate in writing the newspaper article in the radioactivity program.
Competitive strategies	Compete about having the best arguments in the offline debate in the wolf program. Compete about building the most efficient greenhouse in the plant program. Compete with themselves when answering quizzes
Memorisation /rote learning	Quiz about biological facts in the wolf program. Quiz with facts about malaria in the malaria program

3.3.5 Communicating in the language of the youth culture

It is important to try meet young people with effects familiar from the youth culture, and speak a language they understand. We believe that integrating scientific issues and use visual and technological effects from the youth culture might contribute to increase students' motivation and engagement for working with scientific issues. The choice of design and colours in Viten programs, and the use of technological artefacts like cell phone text-messages are based on a conscious choice and an objective to promote active engagement amongst students. In a study of two classes using the radioactivity program we asked the students to list positive and negative comments about the program after completion of the teaching sequence (Mork in prep.). Figure 3.3 shows the students positive comments, which indicate that Viten have succeeded meeting the aims about appealing to the youth culture.

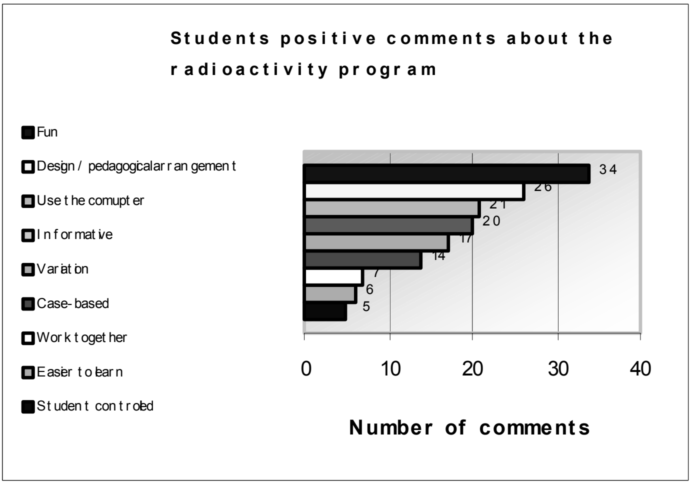


Figure 3.3: Summary of students' positive comments about the radioactivity program. The comments are categorised. 48 students have given their comments.

The categories of positive comments containing 34 utterances showing that the students think it was fun to work with the program, they are positive to design and pedagogical arrangements, positive to using computers in science lessons and last but not least, they think the radioactivity program was informative.

Figure 3.4 shows the students' negative comments about the program. It is worth mentioning that there were fewer negative than positive comments about the program.

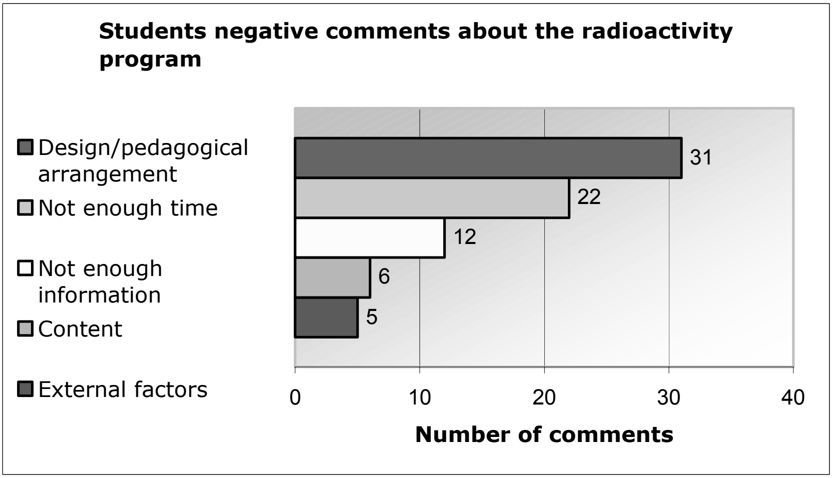


Figure 3.4: Summary of negative student comments about the radioactivity program. Comments are categorised. 48 students have given their comments.

31 negative comments were connected to design and pedagogical arrangement. This category contains statements, which the students themselves classify as negative, like:

English:	*Norwegian:*
"A bit too much to read."	*"Litt mye å lese."*
"Sometimes difficult explanations and definitions"	*"Noen ganger vanskelige forklaringer og definisjoner."*
"The program is to short"	*"For kort program."*
"Too few animations"	*"Litt lite animasjoner."*

As we can see from the citations above, in reality some of them are also positive comments on the program. That the program was too short might be interpreted as if the student liked working with it, in the same way as the comment about too few animations probably means that the students liked the animation present in the program. A lot of students think it was negative that they didn't have enough time to complete the program. Some students say that some of have little explanatory information on what to do, while others think the content was difficult and/or boring. The category external factors is represented by comments on trouble with Internet connections, students were not allowed to choose partner themselves and so on.

3.4 Summary

The objective of this chapter has been to present the theoretical perspectives and principles the Viten project draws upon, and give some concrete examples on how these are expressed in the Viten programs. As described, the Viten programs are complex structures that are not just teaching about scientific content, though that is an important part of it. They are teaching about something that goes beyond the content; they are teaching about education for citizenship in a scientific context, they are teaching about scientific literacy, about decision-making on scientific issues, and they are teaching about evaluation of the presentation of science in the media. The Viten programs aim to promote student learning at the individual level as well as in a group structure where 2-3 students work together at a computer. In addition all Viten programs have goals related to promoting lifelong learning skills and cross-curricular activities (Mork and Jorde *in pres*). If we look at the wolf program, students are not just learning about a socio-scientific controversy in the Norwegian society. No, they are learning much more than that. They are learning what it means to participate in this debate by constructing arguments, by refuting arguments, and drawing upon evidence, looking critically at evidence. This debate also illustrates how language is one of the most important tools we have for supporting learning, and that being able to use scientific information in a real world context is important for student achievement. The Viten project is in an exciting phase where results from classroom research studies are influencing our decisions as curriculum developers. However, as we find answers to some of our questions, dozens of new questions arise. We realize that there is a considerable need for further research; especially larger scale studies that can tell us about the impact of learning environments like Viten in science classrooms.

4
Development of Viten Programs

The Viten design for curriculum development is closely connected to classroom research, thus making Viten a Research and Development (R&D) project. The development of Viten programs is based on the integration of pedagogical and technological ideas for good science teaching. As a curriculum development project we are integrating ICT into the science curriculum using well established principles of science teaching and learning. As science educators our main focus is to provide links between the content of science and the processes involved in teaching and learning science. Information technology is a tool providing great potential to mediate and improve this process.

Viten is also involved in the development of technological solutions for the use of the Internet in science teaching. As the technology advances, so too must our ability to see how subject matter may be benefited by delivery in these new forms. Viten is a multifaceted project involving the development of web-based science curriculum programs, classroom research connected to the implementation of the curriculum in schools and finally, the development of web-based software for delivery of the curriculum.

In this chapter we explore the development of curriculum programs from their inception to implementation studies in the classroom.

4.1
Curriculum development model

In the creation of Web-based curriculum we are working across academic boundaries as Science, Pedagogy and Technology together create an intricate “web” of interaction. It is not enough to have sound pedagogical ideas about how and what to teach in science or to make intelligent electronic delivery systems for the collection and distribution of information. Web based curriculum development requires that teams of people with expertise in areas integrating technology with subject content; pedagogy with electronic delivery systems; classroom research with ICT in schools work together in an environment of idea sharing.

Our research and design activities are based on a continuous improvement model combining development of materials with classroom evaluation (Jorde 1998). There are very few projects in Norway that have managed to work with all of the stages of curriculum development (initiation, planning, materials development, preliminary implementation including classroom studies, revision, release, continuing implementation studies and teacher development) within the same project group simply because this strategy is so demanding. As the Viten project has developed, so too have the component parts of the model.

All Viten curriculum projects are developed in teams consisting of teachers, science educators, ICT technicians and experts from the academic discipline (Figure 4.1). Once themes have been constructed using the Viten software toolbox, implementation studies are conducted in science classrooms where we participate as classroom researchers. In order to understand the challenges faced by teachers and their students while implementing Viten projects, we take into account the realities of everyday life in science classrooms and school systems. We include pre- and post testing as a means of monitoring conceptual growth. We videotape groups of students working so that we can better understand the role of social discourse in learning concepts. We use responses collected in the software program for analyzing conceptual growth while students work with the projects. We interview students before and after their introduction to our projects, trying to understand their views on the use of ICT and their knowledge about actual science topics in contextual settings.

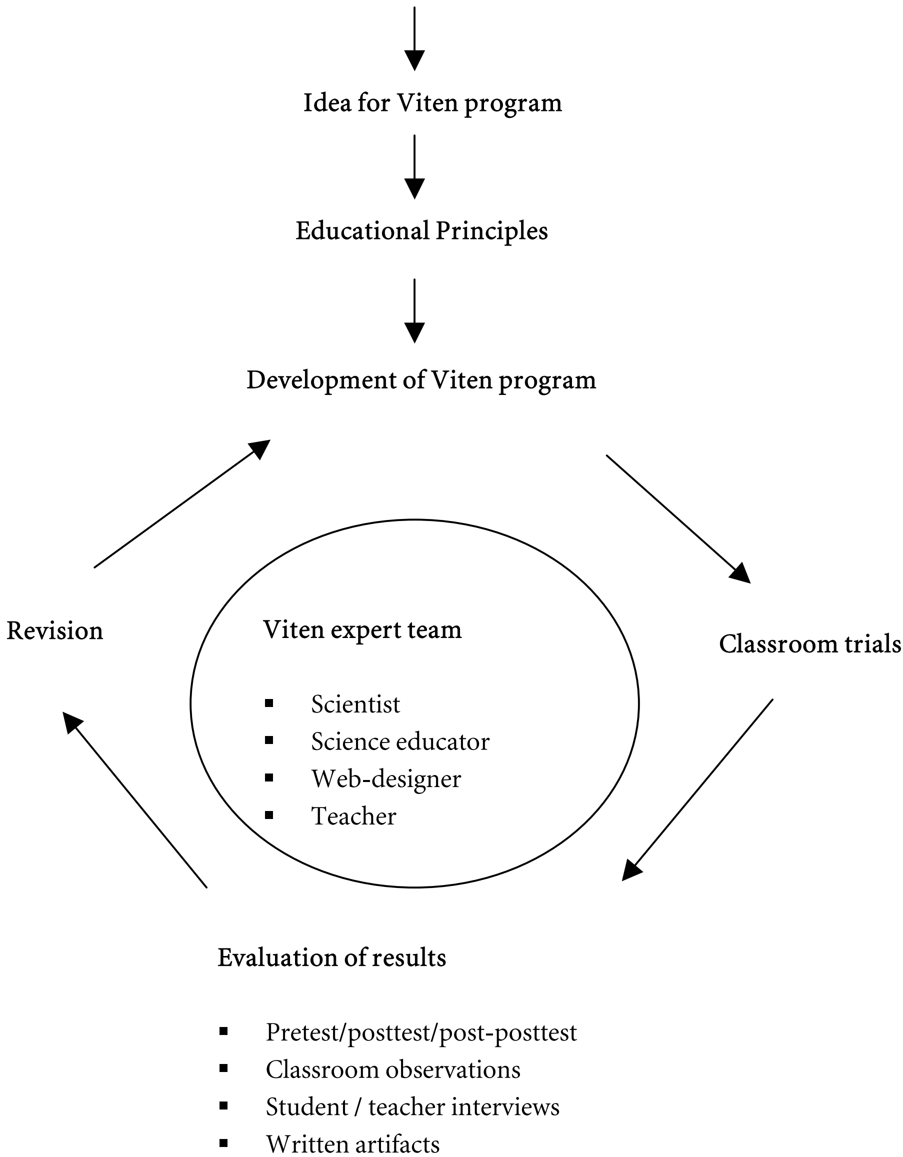


Figure 4.1: The Viten Curriculum Development Model

The case studies are presented in this chapter to demonstrate how Viten programs are developed and evaluated. Wolves in Norway (Ulv i Norge)[11] and Earth Process (Norge blir til)[12] are chosen to demonstrate a continuum in the development process of Viten programs.

4.2 Wolves in Norway

Science educators seem to agree that relevant, real life contexts are an important motivating factor when teaching for scientific literacy. Knowledge about how students deal with such issues is of relevance when designing curricula and teaching models aimed at science for citizenship (Jenkins 1994; Driver et al. 1996; Millar and Osborne 1998; Aikenhead 2000; Driver et al. 2000; Kolstø 2001). 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 (Lemke 2001).

Important aspects of science are the social processes where ideas and results are reported, peer reviewed, debated and scrutinized (Driver et al. 1996; Ziman 1996). There is a need to understand the role of controversy in modern science and its rhetorical functions in handling uncertainty (Osborne 1999). It is therefore vital to teach about the nature of science as a process and a social activity as opposed to teaching consensual textbook science (Mork and Jorde in press).

The question about the continued presence of wolves in Norway is an example of a socio-scientific controversy currently taking place in the Norwegian society.

NOTES

11 Erlien, W. (2001). Ulv i Norge. Internettbasert biologiundervisning med fokus på en kontrovers. Norges teknisk-naturvitenskapelige universitet. Trondheim, NTNU: 172.

12 Arnesen, N. (2002). Gammel jord gjennom ny teknologi. Institutt for lærerutdanning og skoleutvikling, Universitetet i Oslo.

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 working for protecting the environment and many in the general public support the government on this view. On the other side of this conflict are powerful sheep farmers practicing free-range methods who see the re-introduction of wolves as a threat to their economic and personal well being. 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 (Mork and Jorde in press).

In the wolf curriculum we explore the effectiveness of a Viten program for teaching about controversy through the use of discourse and argumentation in science teaching. By introducing students to a socio-scientific issue like the wolf controversy, we are placing science into an authentic context. The Viten program serves as an artefact, connecting information together with students and initiating discourse talk among them. Lemke (1990) claims that amongst other things, talking science also means learning to communicate in the language of science and acting as a member of the community of people who do so.

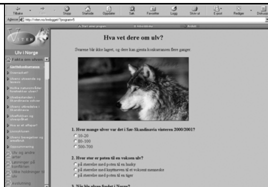
As with all Viten programs we begin by coordinating our subject goals with the goals found in the Norwegian national curriculum (L97). Students in grades 8-10 should be introduced to biological concepts including biodiversity; ecosystems; ecological principles of energy flow, niches, populations, species, abiotic factors; and human effects and social issues related to ecology. We then decided to place these concepts within a controversial issue taking place in Norway, that of allowing for the expansion of wolves. We combined the subject aims together with the need for students to become engaged in controversial issues, and to see the placement of science in the context of the debate.

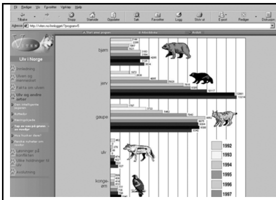
The aims for the Viten wolf program are to introduce students to:

- the biology of wolves and their place in an ecosystem
- the concept of ecological management
- the role of science in a controversial issue
- the importance of working together in groups and talking science
- the importance of using the Internet while learning science (computer literacy)
- participation in an actual debate about wolves in Norway, allowing the opportunity to argue for and against the issues (social literacy).

The expert content group consisted of Professor Reidar Andersen (NTNU), Scott Brainerd (NINA), John Linnell (NINA), all of whom are connected to ROSA (Rovvilt and Samfunn). We thank these individuals for their contribution to the subject content of this program.

Table 4.1: The wolf-program contains 6 main units and an offline debate as a closing activity.

		
Introduction The wolf controversy is presented. Students write about what they already know about this issue.	**Wolves and humans** Students are introduced to myths, fairytales and a scientific report about the danger of wolves. Student activity is to write a note about their own opinions about the danger of wolves.	**Facts about wolves** Contains 11 pages which are a mixture of quizzes, texts, pictures, animations, plotting on a map, note-taking, drop and drag activities, graphical information and links to information pages on the Internet. The ecology of the wolf is presented. Student activities dispersed throughout.

		
Wolves and other species Contains 6 pages with text, animations, a video clip, note-taking, links to other pages on the Internet and graphical sources. The actual conflict of having wolves in the landscape is introduced.	**Solutions to the conflict** Contains 3 pages with text, pictures, note-taking and graphical information. Students are introduced to multiple ideas for the integration of wolves in the landscape.	**Different attitudes towards wolves** Contains 4 pages, 2 interviews from newspapers with people claiming opposite views in the wolf debate, guidelines for how to evaluate the arguments in the interviews and a note-taking activity where the students are asked to evaluate these arguments.
Closing Activity An offline debate is the closing activity for the wolf program where students are asked to play 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 for their role in the debate.		

4.2.1 Methods

Research on the Wolf program included a study of two 9th grade classes (n=59). The computer-based component of the curriculum lasted about 4-5 hours during which students worked together in pairs at the computer. Discussion and cooperation among the pairs was ongoing throughout the curriculum unit. Students were given 2 hours to prepare and perform an offline debate conducted as a role-play, where they were assigned roles either for or against wolves in Norway. During the preparation for this debate students worked in groups of 4-6 students.

A 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 were designed to reflect the content provided by the curriculum, and were carried out individually for all students. Each test has both multiple-choice questions and open-ended questions, based on the learning goals of the teaching program. 10 multiple-choice questions and 7 open-ended questions are the same in all three tests. In addition all the tests contain some questions unique for the particular test. Answers to open-ended questions common to the three tests were coded according to the scheme provided in Table 4.2.

Table 4.2: Coding scheme for open-ended questions identical in all tests.

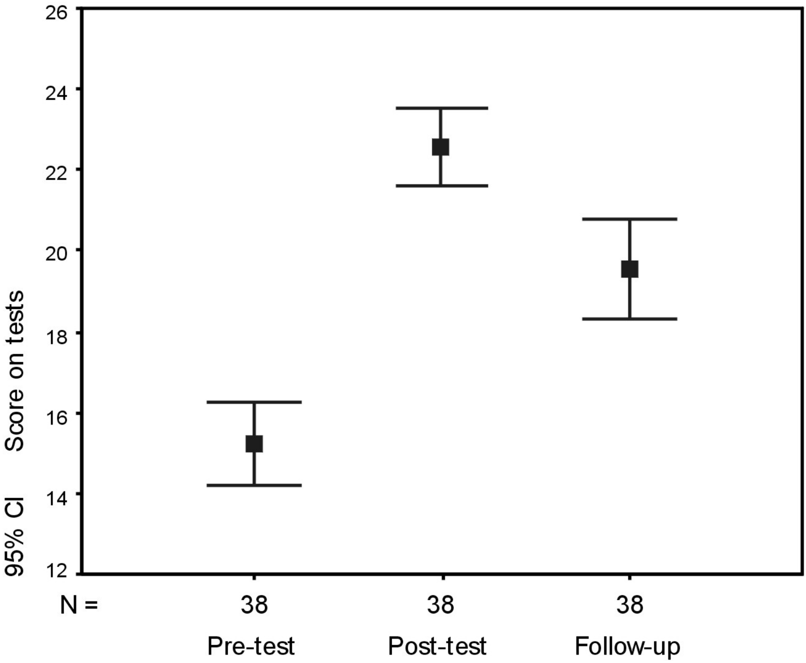
	Questions	Level 1	Level 2	Level 3
1	Are wolves dangerous or not? What is your opinion?	Dangerous/ not dangerous no justification.	Dangerous/ not dangerous In-complete justification.	Dangerous/ not dangerous. Scientific arguments like: dangerous only when provoked and under certain conditions; small chance 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	The woods or mountains	The woods and the moun-tains.
5	Where in Norway do we find wolves today?	One area mentioned.	Two areas mentioned	All the following mentioned: Østerdalen, Østfold and the areas by the Swedish boarder.
6	Why do wolves usually live in flocks?	1 argument.	2 arguments.	3 or more arguments.
7	Do you have any sugges-tions for how wolves and people can live together in the same area?	1 suggestion.	2 suggestions.	3 or more suggestions.

4.2.2 Results

An overview of the results from the individual pre and posttests showed that the students did learn science as described by the curriculum goals (see Figure 4.2). Our research showed that even after 4 months students continued to demonstrate high levels of retention, a finding we are very happy to report.

Figure 4.2: Results from written test scores. Data in this figure represent only the 38 students responding to all of the 3 tests. The Y-axis represents student test scores. Maximum score is 31.



Deeper analysis of the open-ended questions has given us information on where our curriculum has succeeded and where it has failed to allow students to gain what we often refer to as "ownership" of the scientific concepts. We have also begun an analysis of the time spent on individual pages within the curriculum as a means of helping us to better understand what pages attract attention and also create good learning situations for students.

We conclude the wolf program by asking classes to enter into an off-line debate where students assume roles; for and against having wolves in Norway. The analysis of the arguments used in the debate has allowed us to critically look backwards at our program as we map the arguments that are used and those that are overlooked by students. The off-line debate has also demonstrated to us the advantages of "talking science" and making meaning out of text.

4.2.3 Discussion

Our intentions for writing the wolf program were related to ideas of combining web-based curriculum software design together with an authentic controversy in the Norwegian society. Because we followed a pre- and posttest design, we were able to show predictable gains in the biological concepts students retained after working with the program. We were surprised to learn how little our student population actually knew about the controversy before starting the program since it is so visible in the Norwegian media.

We have been interested in tracing student arguments back into the curriculum to gain an understanding of when and where students begin using biological concepts in their writing and conversation. 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. One student had the following comment in her log: *"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."*

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 students became genuinely involved in this conflict and retained biological information even weeks after completion.

The wolf program provides a mixture of information and activities allowing student pairs to make their own selections of information and construct their own texts in the electronic workbooks. Viten serves as an artefact through which information is provided and then transformed into knowledge as students talk to each other about content; something Mercer (1995) would call "the guided construction of knowledge". Afterwards, when preparing for the debate they are processing data from the program and from their own workbook. In the debate students use their knowledge when arguing in the role they are asked to play, and are given the opportunity to use newly gained knowledge in a meaningful and empowering way. As Simonneaux (2001) we experienced that all students expressed enthusiasm for this type of exercise as exemplified by the following in one student's log *"It was good that we could express our own opinions, and the debate was cool."* This is also in line with Kolstø's (2001) observation; that role-playing increased the possibility of understanding other people's point of view when one is placed in another person's situation.

4.3 Earth Processes

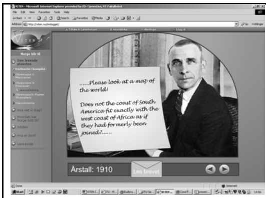
Earth Science is an area of the curriculum that has been neglected in the Norwegian national curriculum for science. The reasons for this are historical in that geology is often placed with geography and thereby taught as a social science. Norway is a country dominated by mountains and other earth formations important for the economical and esthetical value of the country. In the curriculum reform of 1997 (L97) earth science was taken into the science curriculum in an attempt to emphasize its importance as a part of our Norwegian culture. However, since little had been taught in teacher education and little emphasis was placed on earth science in the curriculum, we were faced with a situation that required immediate attention for teachers and their students.

The Earth Processes program (Norge blir til) was started as a master degree project by Nina Arnesen (2002). Upon completion of her degree, the Viten team continued the development of the program designed for grades 8-10.

The national curriculum states that students at this age level should be introduced to ideas and concepts about earth types and their connection to vegetation, rocks and minerals, the changing planet (geological time) and the relationship between weather, water and earth features (earth processes). The aims for the Viten earth process program are to introduce students to:

- Ideas of plate tectonics and continental drift (history of science)
- Earth features including volcanoes, earth quakes, continents, plates
- The geology of Norway as related to the rock cycle and plate tectonics
- The influence of ice ages on Norwegian geology
- Earth types as related to agricultural and industrial uses

The expert group working on the Viten program consisted of Merethe Frøyland, Jørn Hurum (UiO), Olav Fjær (NTNU) and Olav Prestvik (Jordforsk). We thank these individuals for their contribution to the subject content of this program.



The blue planet
Alfred Wegener's work is presented leading to his theory of continental drift.
Students observe three pieces of evidence leading to this theory.

What do we know today?
Students are introduced to the modern theory of plate tectonics, looking at evidence from earthquakes and volcanoes.

How was Norway formed?
Students study the earth processes involved in the formation of Norway; reasons for mountains and fjords. The rock cycle is presented.

 **The Ice Age** A study of the ice age and its implications for land formations. Students look at peculiar land formations related to folk tales.	 **Earth and Soil** Different types of soil and sand are studied and their economic uses.	

Figure 4.3: Overview of the activities found in the Viten program, "Earth Processes"

We included the work of Alfred Wegener and his observations leading to the theory of continental drift to allow students to see how science works as a discipline. By collecting pieces of evidence from various parts of the world, students are able to connect data collection with theory building in much the same way as Wegener did. The fact that we have moved from continental drift to new theories of plate tectonics demonstrates the dynamic nature of science disciplines as new pieces of evidence become available.

In terms of connecting pedagogical goals to technological possibilities, we were especially interested in providing animations throughout the program to simplify the presentation of difficult ideas and concepts in Geology. The program was designed to specifically provide a means of presenting Geology not possible from a text book. Finally, we were interested in helping teachers learn enough about Geological concepts so that they would be able and willing to venture out into nature "in their own backyards" with their students to explore the local landforms.

4.3.1
Methods

Research on the Earth Process program included a study of three 9th grade classes (n=66). The computer-based component of the curriculum lasted about 5 hours during which students worked together in pairs at the computer. Discussion and cooperation among the pairs was ongoing throughout the curriculum unit.

A paper and pencil pretest and posttest design was implemented. The follow-up testing has not been completed as of this publication. Tests were designed to reflect the content provided by the curriculum, and were carried out individually for all students. Tests contained 10 open-ended questions based on the learning goals of the teaching program. Answers to tests were coded according to the scheme provided in Table 4.3.

Table 4.3: Coding scheme for some of the open ended questions in the Geology program

	Questions	level 1	level 2	level 3
1	What scientific evidence do scientists have to support Wegner's theory of continental drift?	Continents "fit" together	One or two additional arguments to "fit" but with vague content	Mentions several pieces of evidence including: earthquakes, volcanoes fossils
2	What is meant by plate tectonics?	Vague description of process	Partial understanding of the process, lacking explanation of moving plates	A theory that the earth is made up of several plates moving in different directions
3a	Are you able to name countries where there are active volcanoes?	Mentions one place, but not country with active volcano	Mentions one country or a known place correctly	Mentions several countries correctly

b	Are you able to name countries that experience earthquakes?	Mentions one place but not a country, with earth-quakes	Mentions one country or place known for earth-quakes	Mentions several countries correctly
c	What are reasons why countries have active volcanoes or earthquakes?	Position mentioned but vague reason	Position near edge of a conti-nent, no mention of plates.	Position at or near a plate juncture
4	Do you know how the Hi-malaya mountains were created?	Vague description of proc-esses	Demonstrates understanding of the processes but does not use cor-rect terminology	Uses plate collisions correctly. Eurasia plate and Indian plate and/or other concepts used cor-rectly
5	Why do you think there are no active volcanoes in Norway?	Vague or unclear answer, misunder-standing	Plate collision mentioned but vague and unclear	Norway far from plate juncture, uses correct ter-minology
6	Why are so many fjords and moun-tains in Nor-way?	Mentions ice age and plate colli-sions. No process described	Mentions ice age and plate colli-sions. One proc-ess described	Mentions ice age and collisions and describes proc-esses correctly
7	Explain the rock cycle using the terms: vol-canic, meta-morphic and sedimentary rock. Use a drawing if desired.	Some words used but without connec-tions, un-clear under-standing.	concepts/drawing used to describe the process but without clear understanding of the parts	Concepts/drawing used to describe the process with clear understand-ing

4.3.2 Results

The pre and posttest results show large differences in what students knew before starting the program and after completion. This is not hard to understand when considering that geology has not been a topic in the curriculum in Norway for this age group and teachers have no training in this science topic. We have incorporated many visualizations in the geology program and their affect on learning needs to be studied further. We hear from students and teachers that visualizations are important in learning concepts. We would like to explore the area of visualizations in more detail to understand how they play a role in the learning process.

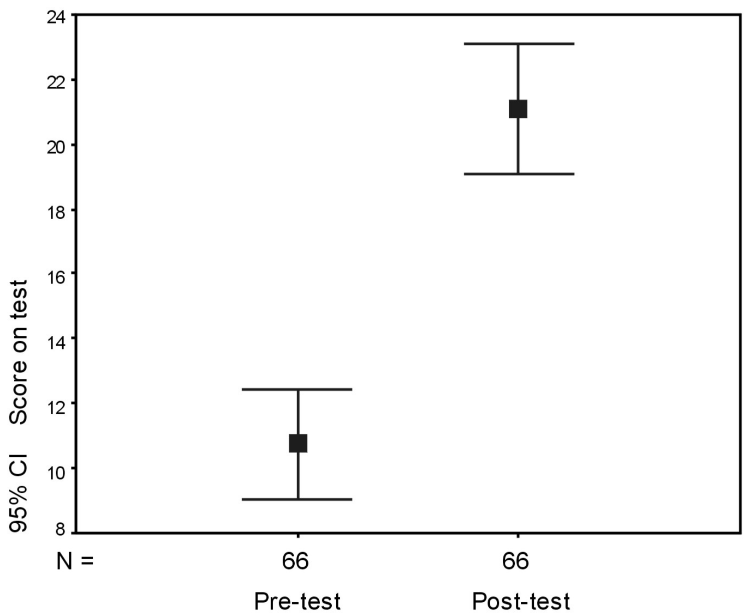


Fig 4.4: Results from written test scores. The Y-axis represents student test scores. Maximum score is 42.

Further analysis into the open ended questions has allowed us to gain a better understanding of the areas of the program where scores improved the most. Greatest strides were made with questions 5, 4, 1 and 3c, all of which deal with evidence for plate tectonics and large earth features. It appears that students were most attracted to the big ideas of earth processes, understanding concepts about plate tectonics and evidence for this. We would like to think that our visualizations helped to improve understanding as well. Questions dealing with details about soil types and their uses were not as well understood; information telling us that we need to revise our efforts here if we want to improve results.

4.3.3 Discussion

We created the Earth Processes program because we knew this is an area of the Norwegian science curriculum greatly neglected. Pre and posttest results were striking. Students have no problem understanding geological concepts at this age group when they are first given the opportunity to learn such topics. We think that the visualizations made possible within the Viten program greatly helped with understanding these dynamic earth processes. Textbooks are not able to capture such dynamic events in their presentation form.

We continue to be challenged with the problem of moving from on-line activities in science to off-line fieldtrips, experiments and observations. In the Earth Processes program we are eager to have teachers move out into nature to observe their local surrounding.

4.4 Summary

In two examples provided in this chapter demonstrate how the Viten team uses information obtained from classroom research to learn about how Viten programs are implemented. Our model of curriculum development is continuous, making use of classroom implementation studies for feedback. Such information is extremely valuable for making revisions of existing Viten programs, helping us to understand what works and what needs to be improved.

Our curriculum development model is an expensive one since we require technical expertise, pedagogical and subject expertise and finally teachers and their students in real classrooms to verify if programs are reaching their goals. We believe this model is justified if we are to continue to deliver quality web-based science curriculum to teachers and their students.

5
Teachers and Viten: Expectations and Experiences

Sonja M. Mork

In this chapter we focus on teachers and their use of Viten. In the first part we look at what teachers expect from new web-based teaching resources. In the second part the focus is on the changing role of the teacher using Viten programs. And finally the last part of the chapter is about how teachers best can exploit the possibilities in Viten programs.

5.1
Teachers expectations to new teaching resources

Our impression is that before teachers are willing to spend time on implementing new web-based teaching material in their science classrooms, there are certain demands to the characteristics of such tools that have to be fulfilled. During our many visits to science classrooms and conversations with science teachers we have identified four criteria held by the teachers as important for new web-based teaching resources. It seems to be of crucial importance for the teachers that the content of the new teaching resource is related to the national curriculum (KUF 1996). Secondly, the tool must be easy to use both for teachers and students, and it must be easy for the teachers to monitor students' work. Finally, the teaching material must be constructed such that by using it, the students learn science. In the next section we will look at these four criteria more in detail.

5.1.1 Content must be related to the national curriculum

During the spring of 2002 we were invited to demonstrate Viten to a group of science teachers at a junior high school. We accepted and asked that they familiarize themselves with the Viten program library beforehand. As soon as we arrived at the school we were met by a science teacher who immediately asked us: *"Why can't you develop teaching programs that are connected to the national curriculum, instead of programs about wolves and malaria?"* At first we wondered if we were working with the same national curriculum since, in our eyes, both of these topics fit very nicely into the wide range of aims in the national curriculum for science and the environment (KUF 1996). But then it struck us that this teacher actually meant that we should develop programs whose titles and content strictly adhered to the explicit goals in the national curriculum. To be sure, the national curriculum does not explicitly state that children should learn about wolves and malaria. However, all of the biological concepts in these two programs are main concepts in the same plan under the disguise of ecology and disease.

Another teacher says the following in an interview:

Excerpt 1: Teacher A: Female in her mid fifties.

English	*Norwegian*
Teacher: Yes, but then I say a little "but" because you know in the beginning I must admit that I wasn't very keen on wolves or malaria for that sake, but it was due to that the first year I had problems with finding time to do things, because the new national curriculum is so comprehensive that we always experience that there are parts of the curricu-	*Larer: Ja, men da sier jeg et lite "men", for du vet i starten, i "barnealderen" så må jeg innrømme at jeg var ikke slå veldig giret på ulv, eller for så vidt ikke malaria, men det skyldtes at det første året så hadde jeg problemer med å rekke ting, for den nye fagplanen den er så omfattende, at vi alltid vil oppleve at det er bolker*

lum we don't find time for. Ehhh, yes, the guiding content that we don't have time for then, so then, yes, yes, I would like to use it, and I might very well use wolves and malaria just to, more as a variation, but I would very much like a content that is very closely connected to the national curriculum accordingly.
Interviewer: Both of them are, because malaria…

Teacher: Yes, I know that under diseases so…. I am aware of that, but then there is this wolf then… (laughing)
Interviewer: There is a lot about ecology in 9th grade then. In 9th grade you also have nature management..
Teacher: Yes, yes, but you know in 9th grade.. We don't have time for these things, because in 9th grade now it is so much, because it is a heavy electronic (electricity) unit, and difficult chemistry and physics, in addition to a quite heavy unit about the human body. Everything…. So we don't have time for nature management…

av pensum vi ikke rekker. Ehh, ja, det veiledende lærestoffet vi ikke kommer gjennom da, så da, ja, jo, jeg vil gjerne bruke det, og jeg kan godt finne på å bruke ulv og malaria bare for, nærmest som en avveksling, men jeg vil gjerne ha veldig læreplanrelevante ting altså.

Intervjuer: Begge deler er jo det for malaria..
Larer: Ja, jeg vet at under sykdom så ….. Jeg er klar over det, men så var det denne ulven da… (ler)

Intervjuer: Det er jo masse økologi i 9.klasse da. I 9.klasse har du naturbruk også..
Larer: Ja, jo men vet du i 9.klasse…. Det der får vi ikke tid til, for i 9.klasse nå, så er det så mye, for det er tung elektrolære, det er tung kjemi og fysikk, i tillegg til et ganske tungt kroppenavsnitt. Altså alt … Så vi rekker ikke naturbruk vi..

These teacher citations illustrates how bounded some teachers are to the textbooks and to teaching about the products of science. However, modern western societies are becoming more and more advanced due to exponential growth in many fields, such as technology and economics. Citizens of today are facing numerous controversies with a science dimension in their everyday lives, many of which involve disputed knowledge claims from the frontiers of science. Therefore students will increasingly need skills for dealing with controversial issues as they prepare to participate in the democratic process, a challenge science teaching will need to face. However, traditionally, science teaching has paid little attention to argument and controversy, even though research into the processes of science e.g. Latour and Woolgar (1986) have confirmed that both argument and controversy are important aspects of the nature of science.

Joan Salomon (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. If pupils are genuinely to understand scientific practice, and if they are to become equipped with the ability to think scientifically through everyday issues, then argumentative practices will need to be a prominent feature of their education in science (Newton et al. 1999). Science education also has an important contribution to make to the general education of students by developing their ability to understand, construct and evaluate arguments. Discussions of socio-scientific issues give students opportunities to consider relevant evidence, develop appropriate arguments and come to reasoned conclusions about issues that impinge directly upon their own lives (ibid).

The Viten programs, and especially the wolf program and the malaria program do not just teach about scientific issues, they also teach about the nature of science, scientific literacy, education for citizenship in a scientific context, decision-making on scientific issues and evaluation of the presentation of science in the media. Themes, all of which are covered in the Norwegian national curriculum (KUF 1996) as shown in excerpt 2:

Excerpt 2

Approaches to the study of Science and the Environment:

- Subjects, which receive a lot of media attention, should be included in their proper contexts. This will help pupils to build up foundations for their own opinions and attitudes. Learning to discuss conflicts of interest, or the ethical and/or environmental aspects of current issues, should be given its place in the syllabus.

Common objectives for Science and the Environment:

- For pupils to acquire insight into natural inter-relationships and the interplay between man and nature, so that they can contribute to sustainable development.
- For pupils to acquire experience in the use of tools, experimental equipment, and electronic aids in a broad range of activities and forms of co-operation. They should learn about seeking, processing and mediating information. They should be able to put their knowledge of the subject to practical uses, and develop the ability to use and evaluate information, technical aids, consumer goods and new products.

The excerpts from the national curriculum say that teachers actually should be teaching about the processes of science, and not just about the products of science which many teachers seem to emphasize in their science teaching.

As curriculum developers we have experienced that compared to the wolf program and the malaria program, it seems to be easier to get teachers to use programs like the radioactivity program, which covers much of the same content that one will find in a science textbook. Our statistics show that in August 2003, 368 teachers have activated the radioactivity program in science classes, while the corresponding numbers for the wolf program and the malaria program are 173 and 118 respectively. The current versions of these programs were all launched in February 2001. It is worth mentioning that the radioactivity program also covers the curriculum for upper secondary school. However, we have an impression that once teachers have become familiar with the wolf program and the malaria program, they will use it again in other classes. For instance, our statistics show that 88 teachers have activated the wolf program in classes with more than 5 students. 52 of these teachers have used the program in one class, 23 teachers have used it in two classes, while 13 teachers have used the wolf program in three or more classes. This information indicates that teachers see the values of the wolf program and experience that it does not just teach about the scientific content, it goes beyond that and also teaches about several aspects of the nature of science.

5.1.2 Teaching resources must be user friendly

An important reason for developing Viten, the Norwegian version of WISE, was experiences from the pilot studies showing that WISE was not as user friendly from the teachers' point of view as we had hoped, especially when looking at options to evaluate student work and provide comments to students. Viten aims to be so user friendly that if you can read and are able to turn on the computer and find the Viten web site, you will be able to use the program in your science classes.

In interviews we have asked the teachers whether the first "log in" of the students went well. The following excerpts are from teachers who were interviewed about using Viten:

Excerpt 3: Teacher B: Female in her last twenties.

English	*Norwegian*
Teacher: Yes, or I had constructed passwords and user names for everybody in advance. So I didn't let them register on their own, which also is an alternative then. But I gave passwords to each individual and then they logged on. There were no problems.	*Lærer: Ja, dvs jeg hadde laget passord og brukernavn til alle på forhånd. Så jeg lot ikke de registrere seg, som er et alternativ da, men jeg delte ut passord til hver enkelt, og så logget de seg på. Det var ikke noe problem.*

Excerpt 4: Teacher C: Male in the beginning of his thirties.

English	*Norwegian*
Teacher: I think it went very well. Everything is very self instructive. Everything one was supposed to do was on the web page, so it was no problem.	*Lærer: Jeg synes det var veldig greit. Alt er så veldig selvinstruerende. Det lå jo på nettet alt man skulle gjøre så det var ikke noe problem.*

Excerpt 5: Teacher D: Female in her late fifties.

English	*Norwegian*
Teacher: Yes, it went very well. They have tried it before also, so…. So it went very well. So I didn't have any problems with that. Of course, there is always someone that has forgotten something, but one can print it out (user names and passwords) and keep it, so it went very well.	*Lærer: Ja. Det gikk veldig greit. De har jo prøvd det før, og så… Så det gikk veldig greit. Så jeg hadde ikke noen problemer med det. Det er jo alltid noen som har glemt noen ting og sånn, men det går jo an å printe ut og ha det, så det var veldig greit det.*

One of the oldest teachers participating in our classroom research and using a Viten program for the first time had been a bit skeptical in advance. In an interview after completing the teaching sequence she had the following comments about the user friendliness of Viten:

Excerpt 6: Teacher A: Female in her mid fifties.

English	*Norwegian*
Teacher: Yes, of course it has to be user friendly.	*Lærer: Ja, det er klart det må være brukervennlig.*
Interviewer: Yes, but it is obvious that it is more demanding the first time one uses it as a teacher.	*Intervjuer: Ja, men det er klart det krever litt tid første gang man prøver det som lærer.*
Teacher: Yes, but me, who hadn't tried it at all then? I didn't find it difficult. I sat at home, because I like to do that, sat a weekend commenting electronic workbooks. And it wasn't difficult at	*Lærer: Ja, men jeg som ikke har prøvd det overhode da. Jeg syntes ikke det var noe vanskelig jeg. Jeg selv satt hjemme, for jeg liker å gjøre det, satt ei helg og kommenterte arbeidsbøkene.*

all. But I had been very nervous about it. Because.... And that's why I say that it has to be user friendly.
Interviewer: But is it (Viten) user friendly enough?
Teacher: Yes, this (Viten) was absolutely (user friendly).
At the end of the interview:
Teacher: No, I say that it turned out much better than I expected, because it was user friendly and that I will be glad to use it again, and that I will use it as a variation anyway.

Og det var jo ikke noe vanskelig. Men jeg hadde gruet meg veldig. Fordi at .. Og det er derfor jeg sier at det må være brukervennlig.
Intervjuer: Men er det nok brukervennlig da?
Lærer: Ja, det her var absolutt det.
Sagt på slutten av intervjuet:
.......Lærer: Nei, jeg sier jo det at det gikk over all forventning godt, fordi det var brukervennlig og at jeg gjerne vil bruke det igjen, og at jeg uansett vil bruke det som avveksling.

These excerpts illustrate the importance of user friendliness when implementing net-based curriculum materials. And when succeeding in using a teaching resource like Viten, teachers often feel more confident about their computer skills and use it again. The teacher in excerpt 6 went on to use the malaria program in two science classes the following school year.

Another aim when developing Viten was that the programs should be available not only from the newest computers and the fastest network connections, but from most of the types of computers and network connections that one finds in Norwegian schools. Norway is amongst the countries in the world with the highest density of computers in schools, but the quality is highly variable. We want the Viten programs to be available for all schools to use, independent of their resource situation. By replacing java applications with flash applications during the process of going from WISE to Viten, the programs are more user friendly and available also to users with older computers and slower network connections. The objective of being available to most Norwegian schools has been a trade-off to the incorporation of video- and sound tracks in our projects.

5.1.3 Easy to follow up students work

Many teachers, especially the oldest generation of teachers, do not feel that their information technology skills are good enough to use a web-based teaching program in their science classes. In addition they know that a lot of students are very skilled at using information technology tools; an uncomfortable situation for many teachers. Our impression is that this might be an important reason why there are not more teachers experimenting with the use of information technology in their science classrooms. Another reason we think teachers hesitate to use information technology in their teaching is the fear of loosing control of the classroom environment. The role of the teacher is definitely changing but this does not mean that the teacher is less important when technology is introduced. We need to take the teachers seriously and provide information technology applications that provide teachers opportunities to follow up student activities and make them feel confident in their own skills.

Viten applications provide teachers with tools that make it easy for them to monitor what students are doing. Teachers are able to follow the progress of student work by accessing the electronic workbook tool and they are able to make comments on student work. The electronic workbook also makes it easy for the teacher to monitor the student work during the lessons. If the teacher is wondering whether students are working on their assignment or not, she can just ask them to open their electronic workbook and check their progress with them. Our impression from classroom observations is that students generally seem motivated and very seldom leave the Viten programs to do other things. But we also have the impression that teachers appreciate the possibility to rapidly view student work during lessons and afterwards. The following two comments illustrate how teachers work with the electronic workbooks:

Excerpt 7: Teacher C: Male in the beginning of his thirties.

English

Teacher: I did look quickly at the feedback pages, but I didn't write comments to them (the students). I chose not to do it because of time constraints, but I did very quickly get an overview of the work they had done, just by going in and looking, without writing comments. So I think that I had at least as good control of how much they did, compared to in a classroom situation. Here I also had the possibility to go to the web at home and look at what they were doing. The advantage is that I don't have to collect their workbooks (paperbacks). And it can also be used to look at their working effort and give an evaluation of that as well, not just the content achievement. Because we also do that in other situations as well. We do collect their workbooks and evaluate their work. So I think that it was very positive that the possibility for that was there.

Norsk

Lærer: Jeg var så vidt inne på disse tilbakemeldingssidene, men jeg skrev ikke tilbakemelding til dem. Jeg valgte å ikke gjøre det av tidsmessige grunner, men jeg fikk jo veldig fort en oversikt over det arbeidet de hadde gjort bare ved å gå inn, uten å skrive kommentarer. Så jeg synes jeg hadde minst like god kontroll på hvor mye de jobbet der som jeg har i en klasseromssituasjon altså. Der hadde jeg jo også muligheten til å gå inn på nettet hjemme og å se på hva de holdt på med. Fordelen er jo at jeg slipper å ta inn arbeidsbøkene. Og det kan jo brukes for å se på arbeidsinnsatsen deres og gi en vurdering på det også, ikke bare det faglige utbytte. For det gjør vi jo ellers også. Vi tar jo inn arbeidsbøker og vurderer arbeidet deres der. Så jeg synes at det var veldig positivt at det var laget en egen mulighet for det.

Excerpt 8: Teacher A: Female in her mid fifties.

English

Yes, I have good control. I have a good overview of what they are doing,

Norsk

Lærer: Jo, jeg har jo bra kontroll. Jeg ser jo ganske bra hva de driver med, og når

and when I go into their electronic workbooks and write comments, then they take it seriously and correct it.	*jeg går inn i arbeidsbøkene og kommenterer, og da tar de det jo høytydelig og retter det opp.*

The students also seem satisfied with the electronic workbooks. The example below is from the electronic workbook of a student pair working with the wolf program. The students worked together at the computer and discussed information found in the wolf-program before they constructed their text in the workbook. The students could at any time maneuver back and forth in the program, and they also had the opportunity to edit the texts in their own workbook.

Excerpt 9: Answers from a student pair's electronic workbook.

Question: How do wolves hunt?
28.02.02

English:	*Norwegian:*
In packs, tactically. All have different tasks. They can also hunt alone, but they don't do this very often and this is also more dangerous.	*I flokk, taktisk. Alle har forskjellige oppgaver. De kan også jakte alene, men det er ikke ofte, og det er også farligere.*
Teacher's electronic response to 28.02.02:	***Larer: Hvordan samarbeider ulvene?***
How do the wolves cooperate? *04.03.02* *In flocks tactically. All have different tasks. They can also hunt alone, but they don't do this very often, and this is also more dangerous.* ***When several wolves are hunting together, one of them diverts the prey, catches its attention, while the others attack the prey from several angels. In this way the prey doesn't have a chance to escape and ends up as food for the wolf pack.***	*I flokk, taktisk. Alle har forskjellige oppgaver. De kan også jakte alene, men det er ikke ofte, og det er også farligere. når flere ulver jakter sammen er det en som avleder byttedyret, får dens oppmerksomhet, mens de andre angriper byttedyret fra flere kanter, på denne måten har den ikke noe sjanse til å rømme og havner som mat for ulveflokken.*

This excerpt shows an example of a student pair that has been editing and improved their text after receiving an electronic comment from the teacher. We are just starting to understand the power of learning environments such as Viten that allow teachers to view student work and provide electronic comments back to students. These comments take very little time to write and are easy to send. As shown in the excerpt, a simple message from a teacher provided enough motivation for one group to improve the quality and quantity of information presented for answering a question.

In our classroom research we ask students to write logs about their work with Viten, or we supplement the post-test with questions about the students' opinion about the program. The feedback from many students show that they loved to read the comments provided by their teachers as exemplified by the following log statements:

Excerpt 10

"It was also good that we got comments from the teacher on the questions we answered, and that *fast!"*

Excerpt 11

"I really liked getting constant feedback from the teacher about the tasks because we could go back and revise our answers a bit"

The students also told us that it didn't matter whether the comment from the teacher was short or long. A comment from the teacher that said: *"Ok"* or *"Good"* was enough for the students to know that the teacher actually had read their answer. They especially thought it was important that the teacher gave comments the second time if they had revised their answer because of initial feedback from the teacher. This illustrates the importance of the teacher when using teaching resources like Viten.

5.1.4 Students' achievement

For any science teacher the content of a teaching resource is very important. But what is the content of science teaching? There is an ongoing discussion in the science education research community about what is, or should be the content of science teaching. Mortimer and Scott (2003) say that 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 the laws and theories, are developed within the scientific community and have been, and continue to be, subject to processes of social validation. However, many teachers seem to be caught up in a positivistic tradition where the focus is on the products of science, ignoring processes as discussions and argumentations. Viten takes this into consideration and intends to teach about something that goes beyond the content; Viten programs are also teaching about education for citizenship in a scientific context, about scientific literacy, about decision-making on scientific issues, and they are teaching about evaluation of the presentation of science in the media.

So what do teachers say about student learning outcomes and the content? The teacher we refer to as "A" has a solid scientific background in "the hard sciences" and more than 20 years of experience as a lower secondary school teacher. She is very self confident about her scientific knowledge and about her skills as a teacher. However, she had not used information technology in her science lessons before and was a bit skeptical to using the Viten Radioactivity program. As the excerpt shows, she was very satisfied with the student learning outcomes, and referred to that many students remembered the visualizations and animations of alpha- and beta radiation.

Excerpt 12: Teacher A: Female in her mid fifties.

English:
Interviewer: What about student achievement, was it as usual or was it different?

Teacher: Yes, it was at least as good as usual….

…..Of course there is a lot of information, but I think that some of them remembered things that they wouldn't have remembered as well after an oral presentation, because they sat quite long periods watching that about the positive and negative charges on alpha- and beta particles, respectively and that sort of thing. So, many students are familiar with that part then.

Norwegian:
Intervjuer: Hva med faglig utbytte, var det som vanlig eller var det andreledes?

Lærer: Ja, altså det var minst like bra…..

……Det er klart det blir mye info, men jeg synes nok enkelte hadde fått med seg en del ting som kanskje ikke ville ha sittet så godt etter en muntlig fremstilling, fordi de satt ganske lenge å så på dette med den positive og negative ladningene på henholdsvis alfa- og beta-partikler og sånne ting. Så det er det ganske mange det sitter ganske bra hos altså.

The next excerpt is from a male teacher in the beginning of his thirties with a background as a biologist. When this study was conducted he was in his first year as a science teacher. He is very positive towards the use of information technology, but as many young newly educated teachers he feels that there are so many other things that have to be done. So he hasn't really spent time getting an overview of available information technology teaching resources for science teaching.

Excerpt 13: Teacher C: Male about in the beginning of his thirties.

English:

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 by chance, 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 lot of individualists. These students really need a lot of practice with teamwork and group work. In a way this program emphasized common solutions. They discussed and came to common solutions and I think that was good.

Norwegian:

Lærer:……… En annen ting som jeg synes var veldig bra, var at det var ikke bare var rent konkret det faglige, men også det at de kunne sitte sammen og diskutere. For det åpnet seg veldig mange gode diskusjoner der de kom fram til ei felles løsning sammen. Og at det på en måte bygger klassemiljøet litt, for det skapes jo relasjoner. Det var ikke bestandig de som nødvendigvis vanker sammen hele tiden som jobbet sammen. Jeg satte sammen par litt tilfeldig, eller ikke helt tilfeldig da, men ikke nødvendigvis de konstellasjonene som vanligvis sitter sammen. Det virket som at de jobbet bra sammen akkurat med dette opplegget. Og den ene klassen er veldig spesiell, for de er en gjeng med individualister altså. Det med lagarbeid og gruppearbeid trenger disse mye trening i. Dette programmet fremhevet på en måte felles løsninger. De diskuterte seg frem til løsninger, og det synes jeg var bra.

This excerpt illustrates teacher C's attitudes towards, and values about science. It demonstrates that his view of the nature of science does not just include the products of science but also the processes of science. He emphasizes that having discussions, cooperate in groups and teams and coming up with common solutions are important aspects of science lessons. These are important parts of the aspects of science that Viten aims to teach about. Teacher C expressed that he was very satisfied with the outcome of the Viten program of radioactivity and he told us that he had recommended Viten to friends that are teachers at other schools. Teacher C also used several Viten programs in his science lessons the following school year.

Teachers did think that their students were learning science content as confirmed by the results from achievement tests in the wolf program and the geology program visualized in chapter 5. In the interview teacher C also emphasized that his students were able to practice their skills in cooperation and discussion during the teaching sequence with the radioactivity program.

5.2
The changing role of the teacher

When we introduce information technology and Viten programs to science classrooms, the teacher role will still be one of the most important factors influencing student achievement. But as the teaching resources or tools change, the teacher role also changes. In the following we give a description of some of the aspects of the teacher role when using Viten programs; regarding preparation for the teaching sequence, what happens during work with the online part of a Viten program, and during the work with the closing activity, often an offline part of a Viten program.

5.2.1
Preparations for science lessons

In traditional science teaching the teacher often puts a lot of effort into preparations for introduction and explanation of a new topic. In addition many teachers also spend a lot of time collecting and adjusting teaching material and preparing student experiments. Then students spend time working with the materials provided by the teacher, and conduct experiments before the teaching sequence is summed up and the students answer questions on a performance test. Our impression is that teachers do not pay as much attention to the summary sequence as preferable and after the test students quickly forget the content of the teaching sequence.

By using Viten, the knowledge base is no longer teacher and textbook, but computer and Internet, and that leads to different ways of working for both students and teachers. When teachers use Viten programs their workload is dislocated in time in the sense that much of the preparations regarding collecting information and preparing student activities is built into the different Viten programs. Thereby the teacher can focus more of her attention on guiding and supervising students along the way (scaffolding).

5.2.2
Teacher role during the online part of a teaching program

Viten is organized so that it is easy for teachers to follow students during their work and give feedback both in the classroom and in the student electronic workbook. Teachers in our study experienced the work with the online part of Viten programs this way:

Excerpt 14: Teacher B: Female in her last twenties.

English:
Interviewer: The student role, if you think about how it is in ordinary lessons, and how it was when you worked with the Viten programs. Was it any difference, or was it as usual?
Teacher: Student role…. The students in a way take more control over the learning situation than they do in an ordinary science lesson. In an ordinary lesson the teacher is much more in charge, more influence than she has in Viten.
Interviewer: Mhmm, how did you experience that as a teacher?
Teacher: I experienced it as positive, I did, because in a way the program took over some of the functions that I would have had in a traditional classroom. (The Viten program) guided the students through the teaching material, and it freed my time, so that I could walk around to the students…

Norwegian:
Intervjuer: Elevrollen, hvis du tenker på hvordan den er i vanlige timer, og hvordan den var når dere jobbet med disse programmene. Var det noen forskjell, eller var det som vanlig?
Lærer: Elevrollen… elevene tar på en måte mer kontroll over læringssituasjonen nå enn de gjør i en vanlig undervisningstime. I en vanlig time så har ofte læreren mer kontroll, mer innflytelse enn det hun har i Viten.
Intervjuer: Mhmm, hvordan opplevde du det som lærer?
Lærer: Jeg opplevde det positivt, det gjorde jeg. Fordi at på en måte så overtok programmet noen av de funksjonene som jeg ville hatt i et tradisjonelt klasserom. Geleidet elevene gjennom lærestoffet, og så fikk jeg frigjort tid og kunne gå litt rundt til elevene….

Teacher B is a female in her last twenties and has been a teacher for 2-3 years. She was one of the first PLUTO[13] students graduating from the Department of Teacher Education and School Development at the University of Oslo. She is therefore an experienced user of information technology. In spite of being a young and newly educated teacher, she is very conscious and reflecting about her teacher role. In excerpt 14 she expresses the feeling of getting more time to interact with small groups of students compared to ordinary classroom situations.

Excerpt 15: Teacher C: Male in the beginning of his thirties.

English:
Interviewer: How was it to be a teacher at the computer room? Did you become stressed or was it ok?
Teacher: No, I think it is ok to be at teacher at the computer room. I like it in the computer room. I think it is important to integrate information technology into teaching, because it is something that you can't avoid. If you in a way have been much in touch with computer technology in lower secondary school it will be much easier for you later in life.

Norwegian:
Intervjuer: Hvordan var det å være lærer på datarommet? Ble du stressa eller gikk det greit.
Lærer: Nei, jeg synes det er greit å være lærer på datarommet jeg. Jeg trives på datarommet. Jeg synes det er viktig å integrere data i undervisninga, for det er jo noe som de ikke komme utenom i det hele tatt. Hvis du på en måte er borti mye data på ungdomsskolen få får du det mye lettere seinere i livet.

Teacher B was very relaxed during the whole teaching sequence, he was very familiar with the radioactivity program and had prepared extra tasks and offline activities for the students. As he confirms in excerpt 15 he seemed very comfortable by teaching science at the computer lab.

NOTES

13 Program for lærerutdanning og teknologisk-pedagogisk omstilling. (Program for teacher education and technological – pedagogical reform.

Excerpt 16: Teacher D: Female in her late fifties.

English:
Interviewer: But I think about when you were in the computer room and….
Teacher: Yes, oh yes…. No, it was fine. I had enough time to walk around and watch there. So I think I had a good overview of the situation.

Norwegian:
Intervjuer: Men jeg tenker på når du var i datarommet og….
Lærer Ja, sånn ja… Nei det var fint. Jeg hadde god tid til å gå rundt å se der. Så det synes jeg at jeg hadde fin oversikt over.

Teacher D is a very experienced teacher with background in biology and chemistry and she has been a teacher for almost thirty years. In spite of her long experience she is one of those science teachers who has managed to keep her curiosity and engagement for science. And she is always looking for new ways to motivate and excite her students. As some of the other teachers she also expressed a feeling of having control and overview of the students and the classroom situation in the computer room. During classroom observations we were impressed with her professionalism, sometimes walking around discussing content related issues with student groups, while other times she sat down reading text aloud to students with learning disabilities and so on.

5.2.3 Teacher role in the closing activity

Closing activities are one of the most important parts of a Viten program. Students are able to use the information they have collected and processed through working with the online knowledge base in the Viten programs. When students enter the closing activity they are supposed to e.g. be qualified to build an adequate green house for growing plants in a space ship, have enough information about radioactivity to write a newspaper article with scientific information and so on. So what about the teacher? Teachers play a crucial role in guiding students through these activities, asking critical questions about green house construction or guiding the construction of off line debates about wolves. These are new roles for science teachers. In the following section we use an example from a study focusing on the offline debate in the wolf program (Mork and Jorde 2003).

In a study from the London area Newton et al. (1999) found that science lessons tended to not include activities that support discussion, argumentation and social construction of knowledge. After interviewing the teachers involved about the place of argumentation in science teaching, Newton et al. concluded that the development of discussion within school science seems to dependent on four constraints; advanced planning, appropriate time slots, a prerequisite knowledge base, and establishment of clear procedures for running group discussions. The Viten wolf program provides teaching material that gives an opportunity to overcome these constraints. The Internet based part of the program is a knowledge base with a collection of information and various types of student activities. The program is self-instructive and allows students to work efficiently with the content. Thereby much of the preparation that teachers normally do when collecting materials for their teaching sessions is already done by Viten, and the teacher can change focus to supervise the students and planning the next part of the wolf program; the offline debate. Teacher guidance in the wolf program also provides suggestions for how a classroom debate might be run.

The teacher plays an important role in a classroom debate, both in managing the debate and by guiding students in their exploration of arguing for and against different viewpoints. Figure 5.1 shows how the teacher contributes in the three debates about wolves. A contribution is defined as a sequence of uninterrupted talk. Approximately half of the teacher's contributions are related to strictly management of the debate. While the other half regards both content and management related interventions in the debate.

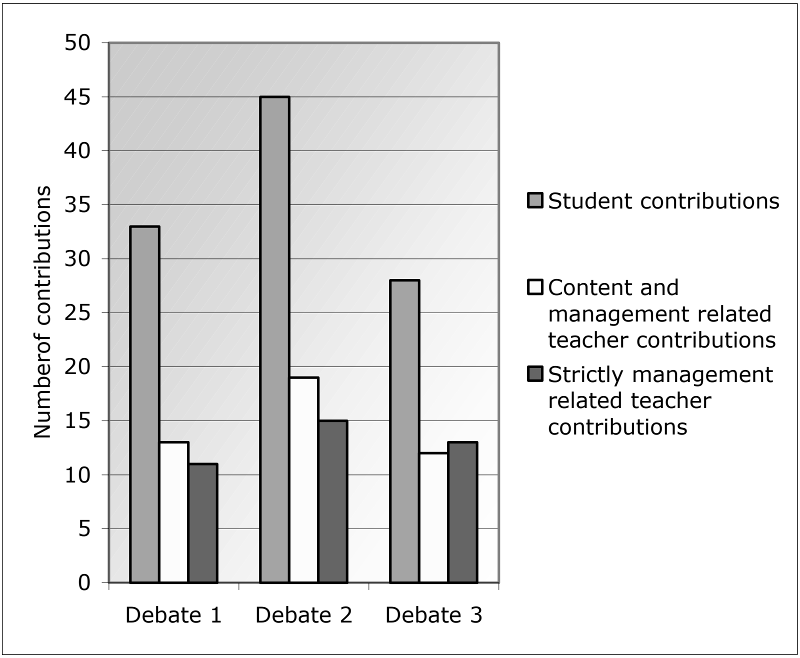


Figure 5.1: Teacher contributions in debates.

In excerpt 17 we present parts of an episode from one of the debates which gives an examples of how the teacher can interact with the students in the debates. The reason for choosing this excerpt is that it illustrates how the teacher assists the students in social construction of knowledge, and it also shows that the way the teacher acts in the debate influences the content of it.

Prior to excerpt 17 is a critical moment where the debate is on the edge of turning away from the original theme. The teacher notices this and interrupts the debate by asking a question related to ecological management, turn 1. The teacher is also addressing the question to one of the groups. In this way the teacher turns the students' attention over to another aspect of the controversy and leads the debate back on the right track.

Excerpt 17: N students are representing groups arguing for wolves, while F students are representing groups arguing against wolves.

1. Teacher: To interrupt you a bit here, how many wolves do you mean that we should have in Norway? How many wolves do you (N-group) mean that we should have? Realistically?
2: Student N4: Between 1000 and 500, because we must have about 500 animals to get a viable pack in a way….
3. Teacher: What do you actually mean by viable pack?
4. Student N4: Yes, not pack, but in a way the whole…
5. Teacher: Population?
6. Student N4: Yes.

L: For å avbryte dere litt der, hvor mye ulv mener dere at vi skal ha i Norge? Hvor mye ulv mener dere (F) at vi skal ha? Realistisk sett?
N4: Mellom 1000 og 500, for vi må ha ca 500 dyr for å få en levedyktig flokk liksom...

L: Hva mener du med levedyktig flokk egentlig?
N4: Ja, ikke flokk, men liksom hele....

L: Bestand?
N4: Ja.

Student N4 uses the concept of viable pack when answering the teachers question in turn 2. To the teacher it is obvious that the student means population, since he is talking about so many individuals, but the teacher seeks to explore whether the student has misunderstood the concept of population, or if he just had forgotten the right word, turn 3. Since the rest of the class is the audience, it is also important to express the right explanation of what a population is. By his answer in turn 4, the student shows that he does know that it is not correct to call it a pack when he means *"the whole…"*, so he has obviously just forgotten the word population, something he confirms in turn 6 after an intervention from the teacher.

From this episode we have seen the following examples of teacher contributions in the debates:

Management and content related:	*Exemplified in turn 1 where the teacher intervenes with a content related question to keep the debate on track.*
Helping students sorting out concepts:	*In turn 3 and 5 the teacher helps the sorting out of the concept of population.*

5.3 How can teachers exploit the possibilities in Viten?

Since the Viten web site was launched in February 2001, we have had the opportunity to meet and talk to many teachers, teacher students and students: the users of Viten. We have met them at conferences, courses, and meetings and some of them have invited us in to their own classroom. Without these interactions, Viten could not have become what it is today. It is of crucial importance that the users of Viten tell us what they like and do not like, as well as what might be done to improve the Viten programs. Experience from the field has helped us to identify certain points that teachers do need to become familiar with before adapting Viten into their personal teaching styles and methods.

5.3.1 Become familiar with the program before using in their science classes

According to our statistics, many teachers seem to use very little time on viewing the different pages in the programs before they use it in their science classes. We think that the best way for teachers to become familiar with a Viten program is to spend time going through it as though they were a student; trying to answer the questions and think as their students. This is the best way to get an idea of the content of the program, the time required and the additional off-line tasks that may be included in the sequence of activities. It is only when teachers are familiar with programs that they are able to customize the Viten programs to their personal teaching styles.

5.3.2 Objectives and the closing activity

As in all other teaching we recommend that students should be informed about the objectives for the teaching sequence before the work starts, and of course that one evaluates whether the goals are achieved in the end. Many Viten programs are designed in such a way that students work towards a closing activity e.g. debating about wolves, building a green house for space, creating an on-line newspaper, etc. It is a good idea to let students know about these activities at the beginning of the project and to plan for enough time to complete them. A part of good science teaching is making the most out of oral and written presentations where students are allowed to share their meanings about their work. As illustrated by some examples in this report we have experienced that students are very positive to the closing activities.

5.3.3 Work in small groups

We strongly recommend that teachers allow their students to work in groups of 2-3 students per machine. Working together maximizes use of the social environment, allowing students the opportunity to "talk science" and discuss their opinions and meanings with their peers. When answering questions in the program, working together allows for differences of opinion.

5.3.4
Teacher ownership

The Viten programs are available to all teachers wanting to use them. Our hope is that teachers learn to customize the programs to fit their own teaching methods and classes. Our experience shows that the programs should be taught over several different class periods with a limited number of activities per day. We do not recommend running through an entire Viten program in one sitting. We ask teachers to be creative! -to add their own personal touch with off-line activities that re-enforce the learning goals from the program; to move outside of the classroom and the school if and when possible; to make use of the additional links provided within the Viten programs for additional projects. In other words, to make the Viten program a component of their personalized teaching sequence.

5.3.5
Electronic workbooks

Viten allows teachers the ability to read student work and give comments. We highly recommend that this is done frequently, providing positive and encouraging comments. Our experience is that a simple comment from teachers often sends students back into the program to improve their work by spending more time on the important concepts, see 5.1.3 for more details.

5.3.6
Cross curriculum teaching

Viten programs are designed for integration across the curriculum. Whenever possible, we recommend combining science with social studies and language, but also religion and art where applicable. The wolf program combines biology with important social issues in the conflict of having wolves in

Norway. This program is also useful for exercises in debate techniques. The plant program is well suited for combining science with art/technology. The radioactivity program might be used in science and language allowing students the opportunity to write an online newspaper article. This exercise opens the door to teaching about genres and critic of sources and the presentation of science in the media. The malaria program is well suited for science, social science and religion. The program gives an introduction to a global disease and the relationship between hosts and parasites. At the same time this program is an excellent starting point for a discussion about actual issues of research on diseases found in developing countries, access to medicine, economic interests and ethical questions related to these matters.

5.4 Summary

We have just started the work with looking into what teachers think about Viten programs, and how they experience to use the programs in their science lessons. In many ways Viten is unique since there are not many web-based teaching resources of this kind in Norway. Viten has been online for nearly two years, providing a growing number of teachers who have used several Viten programs over several years. Our research will continue to look at implementation studies of Viten programs with a focus on how teacher incorporate them into their own teaching sequences and methods. Results and experiences from such research provide an important contribution to development of web-based teaching materials of similar kinds and for other subject areas in addition to science teaching.

6
The numbers are telling a story – the case of Radioactivity

6.1
Introduction

Because Viten is a net based curriculum, we are able to make records of how the projects are being used by teachers and their students throughout Norway. We are, of course, interested in knowing whether our products are being used by teachers. We are also interested in using numbers to provide information on how curriculum may be improved to better meet the needs of science teachers and students.

Figure 6.1 shows a set of standard server statistics, allowing us to follow the use of Viten. It is easy to see differences between weekends and weekdays, when schools are on vacation and time of the day when Viten is used. We have been positively surprised to discover that Viten is often used after 21.00 – by teachers? By interested students? In Figure 6.1 we show a page of special statistics we are gathering on activity within each Viten program. The information tells us how many seconds students are staying on each activity in a program and how they navigate through a program. The color differences demonstrate sorting by girls and boys.

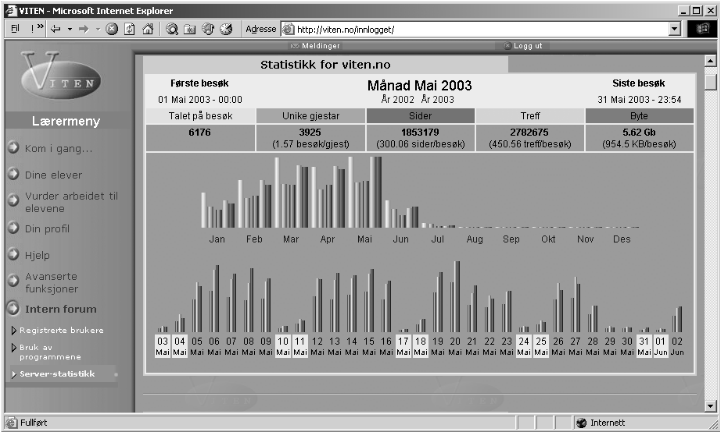


Figure 6.1: Standard server statistics. Number of visits, pages visited per day/monty/year.

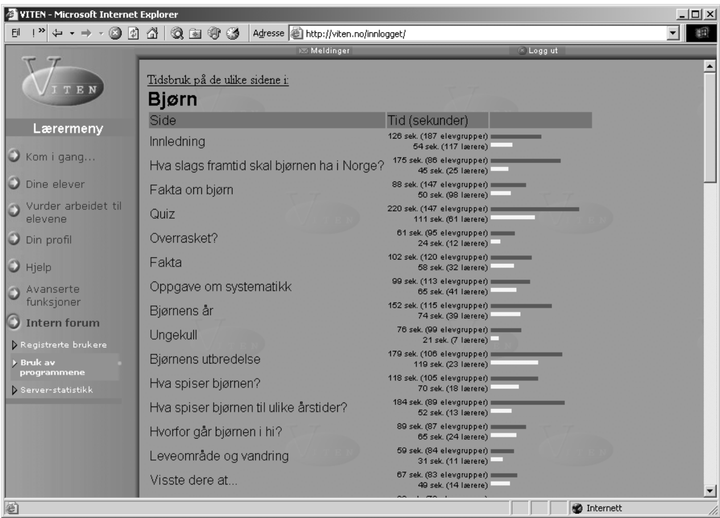


Figure 6.2: Special statistics for VITEN – Average time used and number of visits to pages in programs for teachers and students (may be sorted by female/male). It is also possible to follow patterns of navigation throughout program pages.

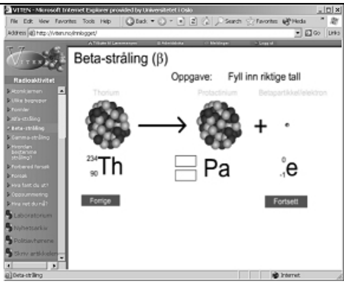
In the remainder of this chapter we choose to look at a specific program in Viten called Radioactivity. We have taken a time period from January 2002 through to June 2003 to collect data on how the activities in the radioactivity program have been used by teachers and their students. We have not been present in classrooms to collect this data. Rather, we have followed the electronic trail from the users of Viten. Data collected for this study is done anonymously in that individuals can not be identified.

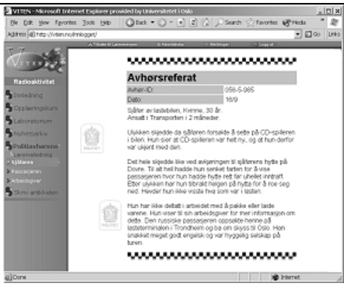
6.2 Radioactivity

The radioactivity program is designed to place science students in grades 8-11 into an authentic context (Hov and van Marion 2002) where they work as newspaper journalists. Students go into their roles at the beginning of the program collecting information for the final article they will be sending to their editor. As one can imagine, most journalists do not have the necessary background information on radioactivity, so they work through a net based course before writing their article. The radioactivity program has six major parts (Table 6.1).

Table 6.1. Description of the six major parts in the radioactivity program

	**Introduction** Students receive a message that a truck has turned over and they are assigned to cover the case. As they get to the site of the accident, they discover the possibility that the cargo may contain radioactive material. They are guided into the idea of collecting samples from different parts of the site (grass, cargo, soil and gravel etc.) to help with the investigation and the news story.

	**Training course** Students follow an on-line course in basic nuclear physics, learning about how radiation may be both beneficial and dangerous.
	**Laboratory** Students carry out several virtual laboratory tests with a Geiger-Mueller counter and a scintillation counter. Their objective is to identify the radioactive material from the samples they took at the crash site.
	**News archive** The archive consists of four relevant newspaper articles on radioactivity. The articles provide important clues to help solve the problem of where the radioactive material may have originated.



Police interviews

Students receive access to police interviews of involved persons. The interviews are designed to help identify the person that placed the radioactive material in the truck.

Write and publish a newspaper article

The final activity includes an on-line newspaper tool. The students (i.e. journalists) use results from the laboratory experiments and other relevant information from the program to present their final article to the editor of the newspaper.

Students are not able to identify the type of radioactive material found at the crash site unless they go through the laboratory analysis with their samples. This step is also essential if they are to complete the program with the final activity of writing a newspaper article. The training course is optional, however most students use the course to both learn about radioactivity and/or revise prior knowledge about the topic.

In order to write a plausible story, students need to understand the underlying theoretical principles of the topic. Since the program appears to have linear structure, it is natural that most students will study this step as well. The final articles produced by students are available for teachers and other students to read.

As in all Viten programs, we have carried out pilot studies during the development of the program. Our studies indicated that students required between 4-6 class periods to complete the program. We also concluded that students should work in groups of two in order to solve the tasks optimally and to gain practice in using the language of science orally as well as in written documents.

We should emphasize that the radioactivity program is the most popular of the Viten programs to date. Our feedback from teachers who write to us is that they are anxious to use the program again with new classes. The radioactivity program was primarily designed to "fit" into the integrated science curriculum for grades 8-10, and is also used in the first year of science in high school in grade 11. The program has been used in 416 classes with five or more students during the period reported on in this study. The classes are distributed between Junior (ages 12-15) and Senior (ages 15-19) High School as presented in Figure 6.3.

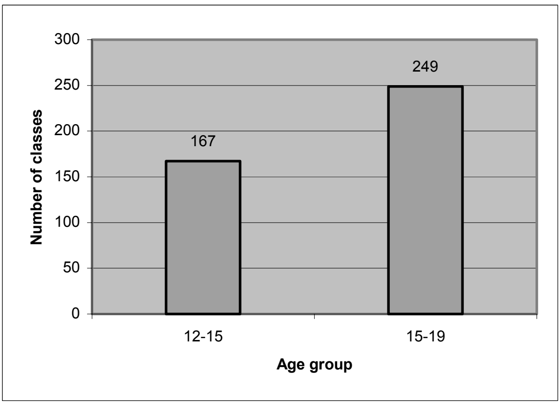


Figure 6.3: Number of classes using the Radioactivity program in Viten. Age group 12-15 represents Junior high school, age group 15-19 represents Senior high school.

6.3
Teacher use of the radioactivity program

A total of 3150 teachers were registered as Viten-teachers in June, 2003. Of these, 1088 had viewed the Radioactivity program as a registered user with 280 actually using the Radioactivity program in 416 classes with five or more students. Figure 6.4 presents the distribution of time spent by each teacher on the program (most likely for inspection and preparation). 698 teachers (64%) were logged in less than 15 minutes before making decisions to use the program.

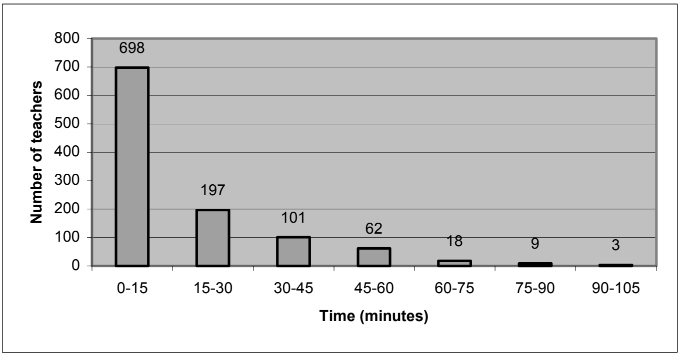


Figure 6.4: Distribution of log-in time for teachers

It should be pointed out that the program consists of 41 steps with varying assignments, animations, simulations and text. A teacher can hardly go thorough the program properly in 15 minutes or less. 193 teachers were logged in for 30-105 minutes, and they probably represent the majority of the teachers that actually used the program in their classes. Teachers are also able to view the program without being registered users by entering through our demo version. Since we are not able to follow statistics on this group of users, the time used by the teachers may thus have been higher than shown in Figure 6.4.

6.4
Student use of the radioactivity program

A total of 8791 students have worked on the radioactivity program during the reported time period of this study. Students are encouraged to work together in pairs. However, they may work alone or in groups of three or more. The data below are based on groups, not regarding the group size.

7034 groups have used the program. Figure 6.5 presents the distribution of group size. 5526 groups (64% of the groups) consist of just one student. It should be pointed out that some students may not have been logged in and yet may have been working in a group. The Viten software does not require that all members of a group are registered, however this is essential if teachers wish to track the progress of individual students. The number of one-person-groups is thus probably lower than recorded.

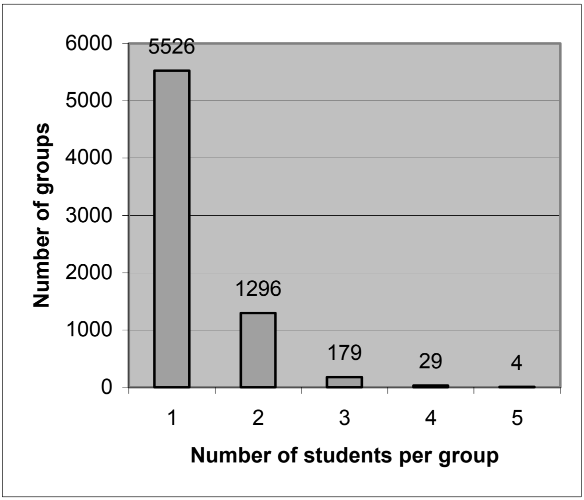


Figure 6.5: Distribution of group size.

As pointed out, a main principle in all Viten programs is that students should be provided the opportunity to learn from each other and preferably should be working in groups of at least two. The data shows us that this is obviously not always the case. The optimal outcomes that we describe from classroom trials may not have been achieved when students were not given this opportunity to carry out tasks together.

The following steps in the program are examples of student work that may be followed electronically and which are important for completion of the program:

1. Collect samples (Ta prøver), part 1. The students are asked to collect virtual samples from the place in question. The samples are analyzed in the virtual laboratory later in the program.
   It is essential to take at least two samples from the area surrounding the truck in order to have "blind" or background values, as well as at least one sample from the cargo. The students are not guided or told where the samples should be taken, nor how many samples they should take. The students may, if necessary, revisit this step in order to get more or better samples.
2. Take notes of laboratory results (Noter lab-resultater). Students are supposed to take notes from three different tests using a Geiger-Mueller counter and a scintilator. In order to carry out and digest the results thoroughly, we estimate the necessary time used on this step to be at least 10 minutes.
3. Write the article (Skriv artikkelen). This is an essential part of the program and we estimate that the students should spend 30-60 minutes on this step. An important part of the program is that students solve this case with help from the information they obtain from the laboratory together with evidence from the police reports. When writing their final article, we ask students to include the type of radioactive matter found at the crash site, the origin of the material and information on how the material came to be found in the truck

4. The final activity is to publish the article with the newspaper tool. After publishing, the articles are available to all other groups and to the teacher. The intention of this activity is to stimulate the students to do their best in terms of showing their knowledge and reasoning on the topic as the newspaper article emerges.

It is of interest to study the time spent on each of the steps to provide an indication of how our classroom trials match with use in classrooms.

Collect samples

Figure 6.6 shows the distribution of the number of samples taken by each student group. The majority of the students have taken more than one sample, thus allowing for ample information on the source of the radioactivity. We are concerned with the 222 student groups taking only one sample. In our revisions of the program we have thus focused on information to teachers about the importance of multiple samples and the need for a sample providing information on background radiation.

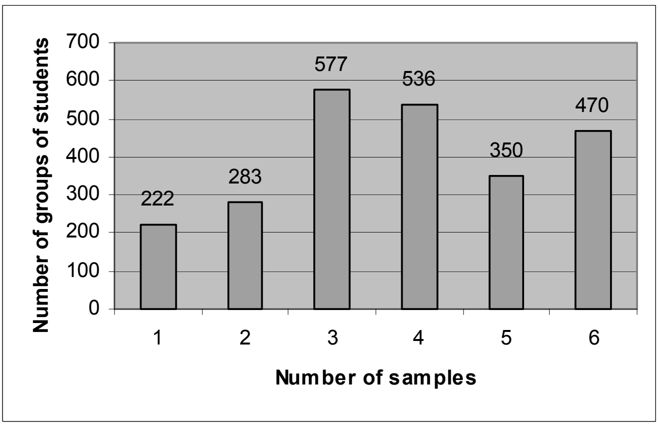


Figure 6.6: Distribution of the number of samples taken.

In Figure 6.7 we present information on the time spent by student groups on taking samples. We can read from our data that the average time spent on this step is 3 minutes and 9 seconds. If students realize towards the end of the program that they have not taken enough samples from the start, they may revisit this activity to collect additional samples. We believe this is the reason for the large number of students spending over 8 minutes on this activity.

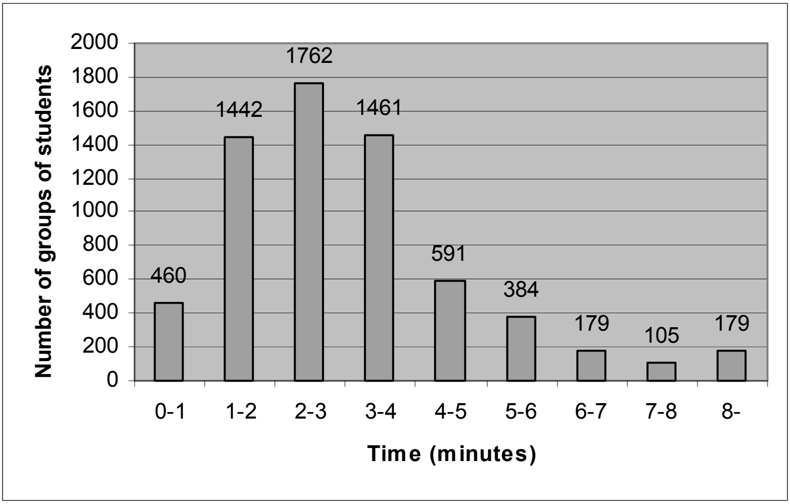


Figure 6.7: Distribution of time spent by groups on the step "Collect samples".

Take notes of laboratory results

The note taking activity requires that students report on lab results from experiments conducted (simulated) with a Geiger counter and a scintillation counter. Time spent on this activity provides an indication of how students are able to interpret and present results from their lab work. In our trials we estimated that students needed about 10 minutes to complete this part of the program. We read from the data that the average time spent on this step is 9 minutes and 27 seconds. We can also read that a large number of students (2398) spent a very short amount of time on this activity and this concerns us since we regard this time be too short to elaborate and interpret the results. These students may have too little evidence to form the basis for writing a plausible story at the end of the program.

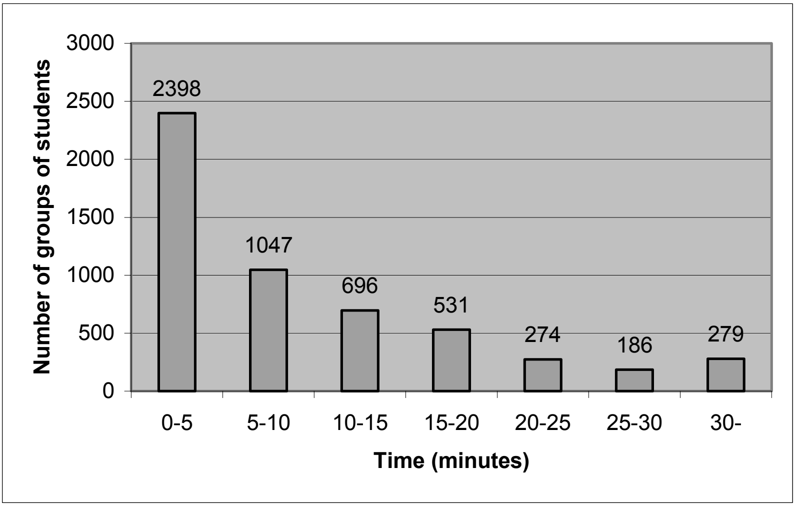


Figure 6.8. Distribution of time used on the step "Take notes of the laboratory results"

Writing the newspaper article

In Figure 6.9 we see that the average time used by the groups to write the newspaper article is 27 minutes and 35 seconds. In our classroom observations, we see that students compose their writing at the computer; a new writing form for many teachers and one that works quite well for students. We are concerned with the large number of student groups who have not taken time on this part of the activity (1613) since it means that they have not been given the opportunity to work with the information presented in this program.

We have tried to find possible reasons for students hopping over the writing activity. Apparently time is one answer – teachers did not allocate enough time for this activity and were ready to move onto another topic. As curriculum developers we see the benefits of integrating writing with science. Apparently not all teachers/students think as we do and would then choose to neglect the writing activity. We are looking at possibilities for including more of the writing tasks along the way in the program so that students will take time to write about their experiences.

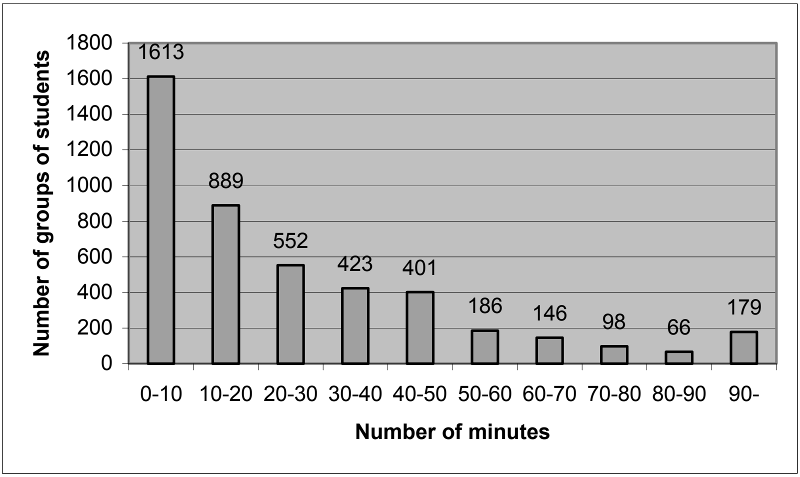


Figure 6.9. Number of minutes used by student groups to write article

Student participation throughout the program

In figure 6.10 we present information on the total number of student groups working with the 4 activities described above. We quickly see that student participation in the Radioactivity program drops off as the program proceeds through the activities. It would seem that the focus from those using the program has been on learning the factual knowledge presented in the program – something that closely aligns with the national curriculum and textbooks for this topic. We see that students are taking time to conduct the lab and work on their newspaper articles, however there is a considerable drop off for actually publishing the finished product in the on-line newspaper. Without completing this last step, students would not be able to share their articles with others in the class.

Writing the final newspaper article provides students the opportunity to reflect on what has been learned and place this information into a context with personal language use. We believe that time is a factor for completion of this activity – not enough time. In our trials we have seen that teachers often move on when some students have completed the program, leaving other students with unfinished products. We would rather see that more time be given to look at each others work as is made possible through the publishing tool.

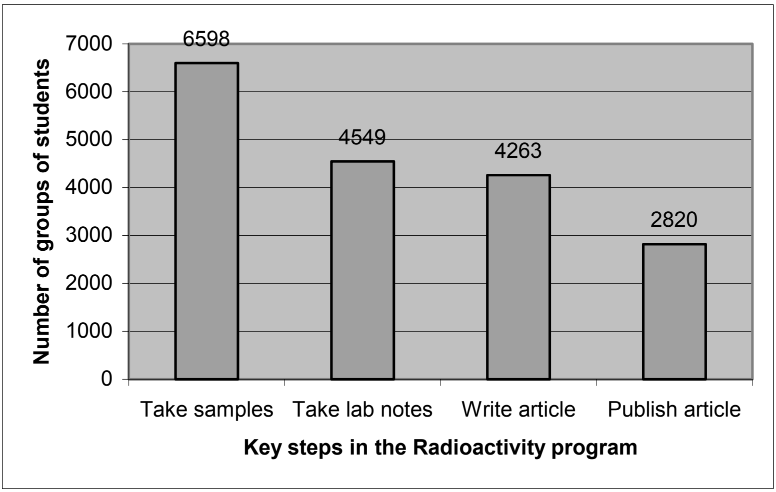


Figure 6.10: Number of groups that have completed four key steps in the program

Total time used on the program

In our trials of the Radioactivity program conducted with 4 classes in 2001, we estimated that students would use between 4-6 class periods to complete the program in an adequate manner, including writing and publishing a newspaper article. Figure 6.11 shows that 20% of the groups have used more than 4 class periods, whereas 47% use less than two.

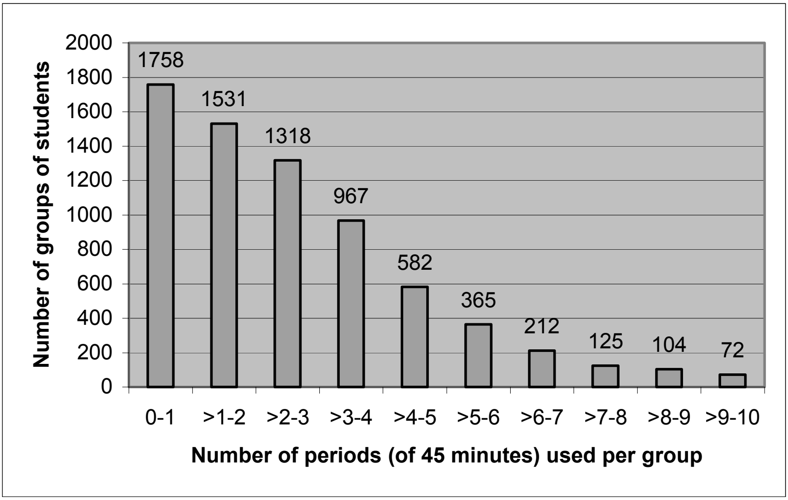


Figure 6.11: Distribution of the time used on the program.

6.5 Summary

In this chapter we have followed the electronic trail left by users of the Radioactivity program in Viten to help us better understand how the project is used by students throughout Norway. The numbers reported tell a story of how students navigate through the activities of the program. This is our first attempt at following the data provided by server information to help us understand how Viten is used in classrooms, and we suggest that development of the tool should be pursued further.

In our interpretation of the data we find valuable information on how we might improve the curriculum in future revisions. We find new and interesting research questions as well. It would be very useful to monitor how the users navigate through the program, following their movements backwards and forwards as they solve the different tasks. Such information may tell us how they learn and think, and in the long run help us to make (even) better programs.

As to the present study it is obvious that many of the users don't follow the program entirely as intended from Viten. However, the program is popular and the fact that teachers choose to use the program year after year indicates that it is an important contribution to the curriculum in science teaching.

We have the chance to combine quantitative studies as reported in this chapter together with qualitative classroom studies to try to explain the significance some of our findings. Of particular importance we can mention the following 4 pieces of evidence that concern us:

- 64% of the students work alone
- The is a steady decline from the number of students starting the program to those finishing the final activity
- A large number of the groups use 30 minutes or less to write the newspaper article
- A large number of the groups use less than two periods on the program

We are pleased with the increasing number of teachers and students using the Radioactivity. We are also pleased to know that the program seems to work for Junior and Senior High school science classes, indicating that we have reached our target group of students. However, we are beginning to have a better understanding of how important teachers are in the implementation of Viten programs and we will need to concentrate our efforts on providing information to them regarding the subject as well as the methods for using Viten program in a more effective way. In other words, there is always room for improvement.

7
What we have learned and where we are going?

7.1
Web based Curriculum Development

After three years of web-based curriculum development and classroom implementation studies, we felt the need to dedicate one chapter of this report to our experiences. In many ways we feel as though the Viten project has been a success. We have all worked hard at making the best possible product available to students and their teachers. We have also made mistakes along the way, often learning things the hard way. We would like to share these ideas with you in this chapter.

As science educators, we enter the field of web-based curriculum development with many pressing issues in our discipline. The number of young people deciding to study in the sciences has been declining in Europe. Females are dramatically underrepresented in the science, both at school and later in career choices. The general public often sees science as the cause of all evil in the world rather than the cure to problems. These issues must always be a part of our awareness as we create curriculum materials that have a chance of influencing the lives of young people. To put it even more dramatically, our curriculum materials could, for some young adults, help them to decide if science is something for them or not in their future.

As we have presented throughout this report, we believe that social-scientific issues are a positive way of introducing science to young people. We start with issues and conflicts that are presently part of the Norwegian society and embed the science within the issues. One could say that we are working from the macro to the micro level of information – from the large controversy to the bits of science one needs to understand the issues. We try to think about girls and boys as we prepare our curriculum stories, hoping to provide a way for everyone to identify with the topic. Perhaps the best way to understand our thinking as we create curriculum is to present some of our own cases as examples.

7.1.1 Gender Perspectives in Viten

The radioactivity program places students into the role of a journalist. The scene opens with two people lying in bed, being awakened by a mobile telephone sending an SMS message. In interviews conducted after our first classroom trial we asked the students if the journalist was a man or a woman….they all answered that it was a man. This, of course, was not our intention since we wanted everyone to feel the possibility that they were personally involved in the case. How could we have excluded the girls? After all, girls are also journalists in Norway so that should not have been a problem for them to identify with. As is happens, the position of the mobile telephone in the opening scene was placed closer to the man than the woman; therefore the SMS message was directed to a man and the journalist was identified as a man. The very simple change of moving the mobile telephone now allows both girls and boys to think that the journalist could have been either a man or a woman. Yes, a very simple change but perhaps more important than we ever realized. Imagine if we had never asked students the question about gender!

Figure 7.1: Placement of the mobile telephone does make a difference!

When creating the Sinus program, we wanted students to work in a water/wave laboratory setting together with a scientist from a research environment. I suppose it goes without saying that we chose a woman to play this role. Her original name was Guri Bolgestad; a cartoon type character with a playful look. Guri has now been transformed into a figure who looks more like a real scientist. Her name is now Berit Bolgestad We made this design decision based on the need to provide role models that young girls are able to identify with if they too are to see themselves as research scientists in the future.

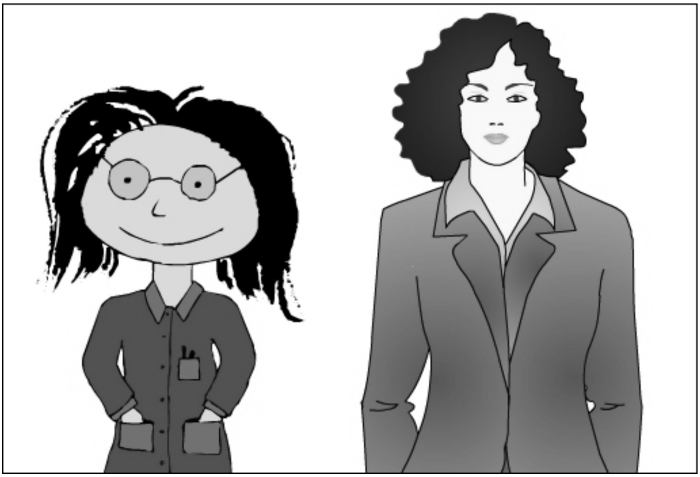


Figure 7.2: From Guri the cartoon figure to Berit – creating a female scientist image

In a final example we look at the Plants in Space program. Traditionally, botany is an area in science that appeals more to girls than to boys. In designing the program we wanted to find ways to attract the interest of all students. Our solution was to create a situation in which a spaceship is traveling to Mars and will need to provide its own food sources due to the length of the journey. Students learn about plants on earth and how they grow, but they do this in order to design a greenhouse within a spaceship. In the final activity students actually build the greenhouse and provide reasons for their choices of construction based on scientific concepts related to plants. We believe we have successfully attracted the attention of girls and boys in this curriculum program by intentionally considering this issue at the beginning of the design phase.

Figure 7.3: Students building models of a greenhouse designed for a spaceship

7.1.2 The Nature of Science Perspective

We have a responsibility to present science in a responsible light for young people. It seems that we tend to present science in textbooks as the “enemy of the people” often presenting a hidden curriculum of negative texts and pictures (Knain 2001). As curriculum developers we need to be especially attentive to the type of picture we are presenting through our own texts, examples and pictures.

During the initial planning phases of the Radioactivity program, the scenario was planned around a submarine accident off the coast of Norway. To be sure, this could (and was) an actual event and a very scary one as well. A decision was made to change the accident scene to a truck rolling over and, at the same time, the unknown radioactive material was chosen to be that which is found in smoke alarms. The science is still the same but the scenario is not as dramatic and allows us to associate the concept of radioactivity with something useful in society. We think this decision will allow students to concentrate more on the science to be learned rather than the political implications of submarines off the coast of Norway and the danger they present.

In the Cycles of Malaria program we could easily have set up a program that stopped at presenting the complex biology of the three organisms involved in malaria. There is more than enough exciting material to present about this complex story of how the malaria organism literally "uses" the mosquito and human for its own benefit in completing its lifecycle. However, the decision was made to also include the social aspects of this complex sickness. Malaria is found in those parts of the world that are most often classified as developing countries. Facilities that are able to conduct research on malaria are found in rich developed countries where the sickness is not a problem. We designed the program such that students would also see the need to science and scientists to be responsible actors in the state of the world. The Malaria program, as is also true of many of the programs in Viten, combines science with social sciences.

If we return to the Sinus program and Berit Bølgestad, in our original drawing of the female research scientist the character was wearing a white lab coat. Research conducted around the world on young people's image of science conveys pictures of crazy bald males, and always wearing white lab coats. We quickly transformed Berit Bølgestad's attire to normal clothes. Again, a small change but perhaps an important one in helping to create positive images of science and scientists for young people.

7.1.3 Pedagogical issues

There have been many changes in the "look" of the pages in Viten from its inception in 1999 until today. If we look at original activities developed within WISE and compare with our current work in Viten, the greatest visible changes are found in how we present text together with pictures. Programming within Flash has allowed us to incorporate ideas on form, color, movement and text in ways that were not possible with only HTML and Java script coding. Other changes come about as we listen to the feedback provided by students and teachers. In the following paragraphs we provide a few examples of important changes to the Viten programs.

Viten may be considered a type of Learning Management Content System (LMCS). Teachers and students are able to communicate with each other as they are using the programs. Perhaps the most important improvement to the software has been the ease with which teachers are able to view student work, providing comments that are then easily available for students to read. This possibility allows teachers to give immediate feedback to students and correct problems along the way. In our research activities we have seen that small comments from teachers has meant that students revisit their work and make substantial improvements. Teachers need time to become comfortable with this form of evaluation and interaction. Students comment that immediate feedback is something they are not used to and really appreciate receiving.

In our initial classroom trials with the Cycles of Malaria program, students commented very often that there was too much text to read on the screen. We know that this is a much discussed issue within language studies and there seems to be little consensus on what is "best" practice. In our own work we have tried to understand the placement of text on the screen and find ways to present texts that are not just boring scroll-down screens of words. In the Cycles of Malaria program originally presented a long text about a young boy named Kofi growing up in Africa and who had malaria. Student log books told us that we had too much text in the program. We have revised the presentation of the text to a web-based story book format. The size of the text is larger and students click to the next page rather than scrolling down (something that has allowed students to work better in pairs since they now wait for each other before moving on). The length of the story is exactly the same as before but it is now more accessible for students to read on a screen.

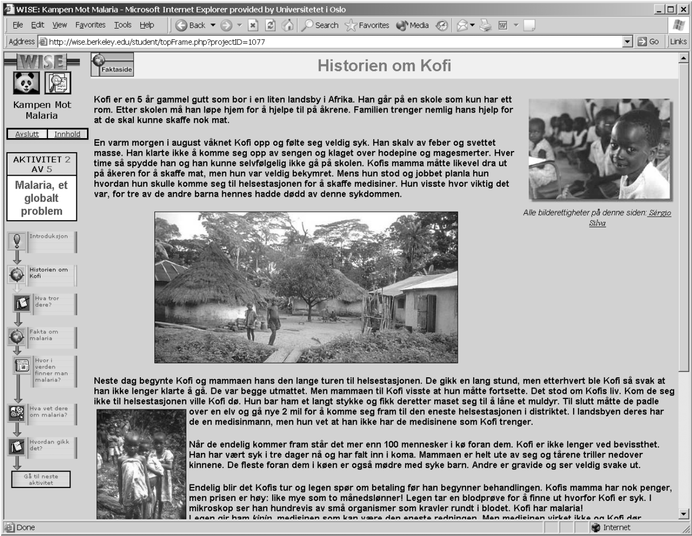


Figure 7.4: Original text about Kofi. Students scroll down to read text.

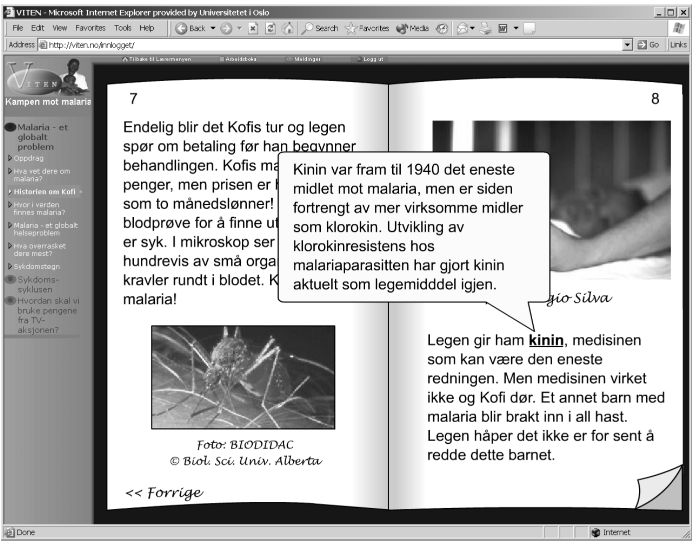


Figure 7.8: Revised layout of Kofi story. Students click to move through the text.

We have deliberately made the decision within the Viten project that texts should never scroll down if we can find other solutions. We call this working horizontally or “into” the program rather than scrolling vertically. The following pictures demonstrate some of the techniques we use for presenting text in our horizontal structure. Notice how activity pages have become more animated, more colorful and more interactive than the original work done with the Malaria project.

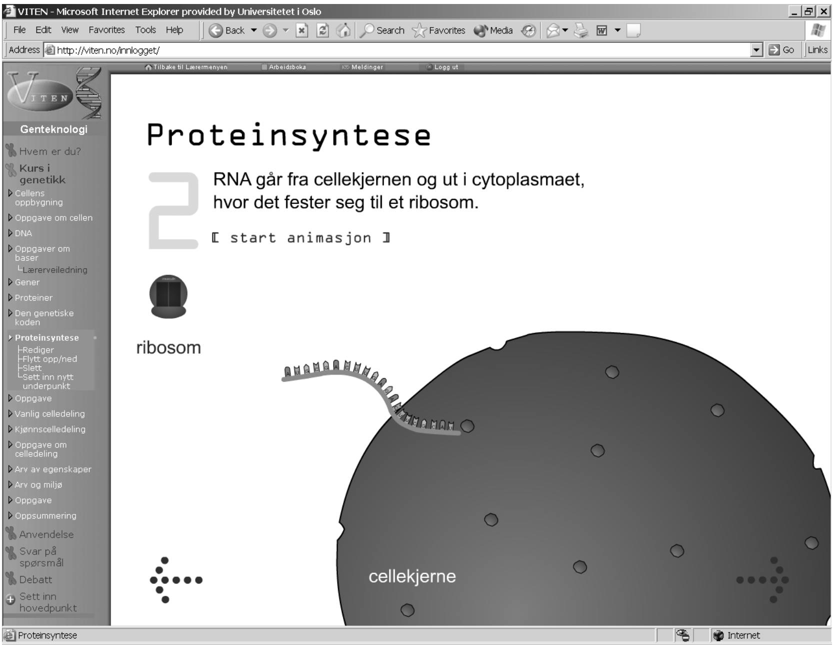


Figure 7.9: When students click on the arrows, they receive new activity pages. In this case clicking shows the various steps in protein synthesis.

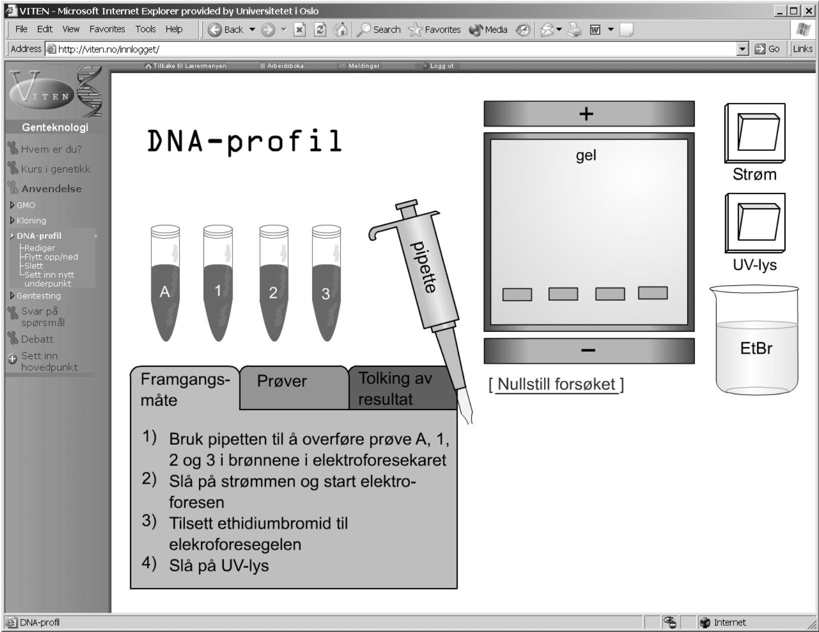


Figure 7.10: Students are able to move the pipette from unknown solutions to the gel area. All of the objects are interactive and are required to complete the simulation.

7.2 Summary

There is still so much to learn. How far are we able to take the technology and still deliver a product usable in schools? How can we develop activities that are attractive to students so that they will enjoy and yet be challenged by learning about science topics? How do we weigh the demands teachers place on the curriculum compared to those of their students and curriculum developers?

These are questions not easily answered. We are working within at least three different disciples in the Viten project as we develop curriculum materials and conduct classroom research: Science education, information technology and general pedagogy. There are tensions within each of these areas that push and pull at the same time, making our work exciting and challenging. There are still many programs to be written and problems to be solved in the area of web-based curriculum development. Hopefully the Viten team will be players in this important field in the future.

We end our report by thanking ITU for supporting the Viten project and for allowing us the opportunity to work on improving the teaching of science through this exciting new medium.

8
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