Some aspects of web-courses in mathematics based on PC screen recorded video lectures

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In this paper we will describe and discuss two graduate level web-based mathematics courses based on PC screen recorded video lectures. These courses have been developed by the first author of this paper and followed by master's students at the Narvik University College since 2001. Comparison to other available courses is made. We argue that the technical solutions, our personal positive experiences and didactical ideas (e.g. concerning the physical presence of students and teachers in addition to instruction by video) in relation to our concept constitute an interesting field for mathematical education research.

The paper presents a practical mathematical teaching experience of the first two authors, which is seen, by the third author, as worthy of mathematics educators' attention and more systematic research. So far (2007) about 200 students have taken the web courses that we describe here. The courses are continuously developed and improved using feedback from the students. The first author now feels confident that the learning outcomes in the web-based courses are better than in the standard classroom teaching that was used earlier and they wish to share their experience with the readers of this journal. Students who are used to studying mathematics via web-courses have sometimes characterized these two courses as 'real' web-courses in the sense that they combine the best features of online courses and ordinary classroom teaching[1].

The so far positive experience emboldened the first two authors to implement the concept in an already developed web course in applied

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mathematics at Luleå University of Technology for secondary school mathematics teachers. Moreover, since 2002, they have started to use parts of the web-concept in the education of students at the doctoral level both at the Narvik University College and the Luleå University of Technology.

The paper is organized as follows. We start by describing the main motivation for introducing this way of teaching a graduate mathematics course. Then, we describe the courses using the 6-dimensional model of web-courses developed by Engelbrecht and Harding (2005b). We then discuss a possible evaluation of the courses based on a taxonomy proposed by Seidel, Perencevich and Kett (2005). Much attention in the paper is devoted to details related to the hardware and screen recording software used in the courses, because poor choices in this area may radically discourage mathematics departments from developing web-courses. We conclude the paper with our plans to apply the concept of web-courses to other courses, some recommendations regarding the use of the concept of web-courses and we call for more systematic research into this developing practice of teaching mathematics in the digital era.

We like to mention that the paper was submitted for publication September 2003 and the present version has only been updated and complemented in 2007 on some obvious points regarding the description of the courses. In addition, a more substantial revision has been done concerning the evaluation of the courses from a mathematics didactics point of view.

Web courses

An overview of initiatives involving web based courses can be found in Engelbrecht & Harding (2005a, 2005b). A less recent publication is the report by Reeves (1998). There is also a report of The Fields Institute's *task force* on on-line mathematics courses[2] (Gadanidis et al., 2002). It would be impossible to summarize these publications in the frame of this short paper, so we will only describe a few examples, making an effort to highlight similarities and differences between them and the courses that are the object of description in this paper.

One example is the elementary linear algebra course called *Vectors and matrices* offered online by eConcordia[3], a Canadian federally-incorporated company owned by the Concordia University foundation. This company offers online versions of the university courses in various subjects. *The vectors and matrices* course is, so far, the only mathematics course at eConcordia. The on-line material of the course is made of 20 units or 'lessons'. Each unit starts with a very brief video showing the professor sitting at a desk and giving a verbal introduction to the mathematical topic, together with some advice on its learning. The professor does not write anything; he does not enter into any mathematical details. The details are given in the form of a (hyper)text, which looks like a textbook with the addition of electronically graded quizzes and tests. There are thus no PC screen recorded video lectures in this course. For the authors of the present paper, however, the process of writing (not typing) mathematical symbols and doing calculations by hand while thinking and talking about a mathematical concept or problem, is an intrinsic aspect of mathematical practice and mathematical communication. Hand writing cannot be replaced by presenting ready-made formulas; it can only be complemented this way (see Misfeldt, 2006). Another difference is that, in the eConcordia course, there are also no face-to-face encounters among the participants except when they all get together for the final examination. All other communication is by e-mail. The courses take place in 'virtual classes': indeed, eConcordia is a 'virtual classroom system'. But in the design of the web courses described here it was assumed from the outset that face-to-face interactions between instructors and students play an important role in the courses and students still form a real social group, where they learn with and from each other. The importance of this social aspect of mathematics learning has been stressed in mathematics education research for many years now; it is also confirmed in the above mentioned doctoral research (Misfeld, 2006).

Jonathan Lewin, a mathematics professor at Kennesaw State University, has developed a course where screen-recorder software is used to produce narrated videos of his classroom proceedings and produce supplementary movies for his book. He uses the computer screen and the Scientific Notebook software as his 'white board', and records all on-screen figures and text and in class audio in his two-hour lecture. An hour after class, he leaves CDs with recordings of the lectures outside his office for the students. Professor Lewin has also included 50 videos on a CD-ROM that is included with his book, *An interactive introduction to mathematical analysis*[4]. There are obvious similarities between Lewins approach and the one described in this paper. However, in contrast to the videos we are using, his videos don't contain ordinary 'whiteboard' writings, screen-recorded animations and simulations made using software such as Scientific Workplace, Maple, Finite element programs, Fractal programs, Complex Analysis programs, PowerPoint etc. Our videos also contain events such as the collapse of Tacoma Narrow bridge or material illustrating the theory, for example a video showing the bending of actual beams and plates.

After the submission of this paper in 2003, there has been a development in this area, and a lot of new web-courses in mathematics have been established or improved. One interesting example is the DELTA project – *Matematikk deltidsstudium på nett* – at Norges Teknisk-Naturvitenskapelige Universitet[5], which is probably familiar to the readers of this journal. The courses contain several videos with 'whiteboard' lectures. However, the technology is different and the screen (which is very small) is updated only once every third second. In our opinion this makes the lectures more difficult to follow. The technology we are using enables us to use a large screen with continuous movements, even with very low bit-rate, and gives (in our opinion) a more realistic classroom-situation. Moreover, the videos don't contain animations and the other screen recorded activities mentioned above. In addition, there are no face-to-face interactions between instructors and students.

Another new example is *E-læring på nett*, powered by Amendor[6]. These courses contain a collection of math-videos which look more or less like PowerPoint-presentations. The videos don't contain any screen recorded activities and there are no face-to-face interactions between instructors and students. The player used for showing the videos is Adobe Flash Player 9, which utilizes new and extremely fast streaming technology. If it turns out to be possible to record, in an easy way, 'whiteboard' lectures, animations and other screen recorded activities and then view the result in the present or future versions of Adobe Flash Player, this could be a good alternative to the software we are using in our courses.

Motivation behind the introduction of web-courses

Dag Lukkassen, the first author of this paper, is a professor of mathematics at Narvik University College. He has been teaching courses in complex analysis and partial differential equations for some years now. In 2000 he realized that computers, the available software and the speed of the internet connections had reached sufficiently high level to start realizing something he had dreamt about since he was a master's student in Trondheim in the 1980s: Imagine how nice it would be to have all the lectures in a course available on video in such a way that every student had unlimited access to them and could watch them anywhere and any time they wanted! Unfortunately, at the time (1980s), this was practically impossible.

Now, with the new technology, the realization of the dream became possible and so he engaged in the development of web-courses. He thought that such courses would benefit all students except, perhaps, those who understand the lecture on the spot, have photographic memory, never need to review the lectures, are never ill and are able to attend all lectures. There are not very many students like this.

Description of the web-courses

The first author now has two complete video-courses in mathematics (in Norwegian) in the fields of complex analysis and partial differential equations. All videos can be seen as streaming videos on the internet. Actually, they have a separate web-streamer so that all students can see them simultaneously. These courses are not taught in ordinary classrooms anymore. They follow the same scheme as all other master's level mathematics course at the Narvik University: two weeks of intensive teaching (5 days a week, with a 4-hour lecture followed by a 4-hour problem solving session each day) + two weeks where the students study on their own (with access to the teachers). However, the ordinary classroom lectures are replaced by PC screen recorded video lectures.

The first author was aware of the dangers of web-courses based on video-taped lectures, such as those described by Engelbrecht and Harding (2005b) as follows:

> Even excellent lecture-driven courses become tedious and ineffectual when converted to electronic page turners. [...] The difference

Figure 1. *Students following screen recorded video-lectures with headphones connected to the PC.*

> between being physically present at a good lecture and reading the transcribed text of the same lecture is vast [...]. (p. 255)
>
> There exist web courses that are still based on lectures that are videotaped and students watch the lectures when and where they can, reviewing the same part as many times they want. This teaching style is not much different from the instructivist style of teaching – in fact, one could argue that web-based courses such as these could provoke a return to a backward pedagogy, with learner's participation reduced to reading and individual work on exercises. (p. 255–256)

In order to prevent this from happening in the web-courses, every schoolday morning, the teacher holds an ordinary classroom session with the students, where students can ask questions and where special attention is paid to topics students have difficulties with. Afterwards, students go to their computers (with headphones) and continue listening to the videolectures at their own pace (see figure 1).

Students can always make a pause in the video, rewind it and review the more difficult sequences. The teacher is available for the students to guide them individually. The students can also call the teacher via the Netmeeting software which is included in Windows 2000/XP. By using Netmeeting the student and the teacher may speak to each other through inexpensive microphones/headphones; they may also share any types of software. For example, the student can point to the part of the

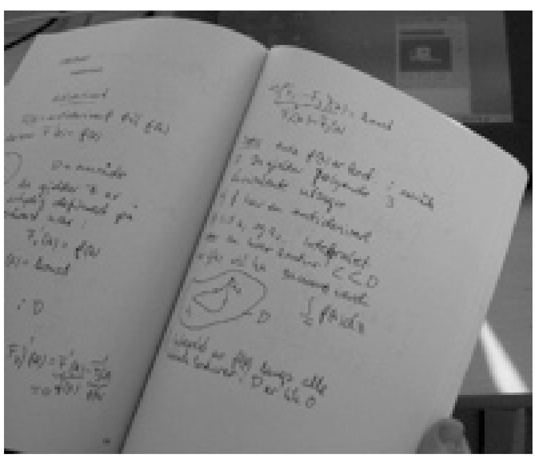

Figure 2. *Students can buy lecture notes (like this) or download them as pdf-files free of charge*

video which he/she doesn't understand, and the teacher can explain by writing on the virtual whiteboard in Netmeeting by using the Wacom's Cintiq tablet (see below for details). Students who like to work in larger groups can watch the videos in special meeting rooms using a projector and loudspeakers. Some students watch these videos at home or from a long distance, and they also may reach the teacher using Netmeeting in exactly the same way as the resident students. Thus, the time previously allotted to lectures is now used for individual guidance. The students may also buy a compendium containing all lecture notes (see figure 2). Alternatively, lecture notes can be downloaded as pdf-files from the web-page of the course.

We will now use the Engelbrecht-Harding radar diagram (2005b) to represent the degree of onlineness of the two web-courses (see figure 3).

Dimension A – *Dynamics and access* – is the highest possible: daily access to the web-site is necessary for the student to succeed in the course. However, we must remember that these are intensive, four-week courses, with a new lecture every working day in the first two weeks. During this period, students must access the web-site to view the lecture; they do not access it to re-view it only and work on exercises. It is only in the subsequent two weeks of study that access to the website is optional and is used to review the material.

Dimension B – *Assessment* – is the lowest possible: no assessment is done on-line.

Dimension C – C*ommunication* – is low but not nil: students can consult teachers online, as explained above.

Dimension D – C*ontent* – is at the medium level: the textbook and lecture notes are available online. All information concerning each course, all exercises with

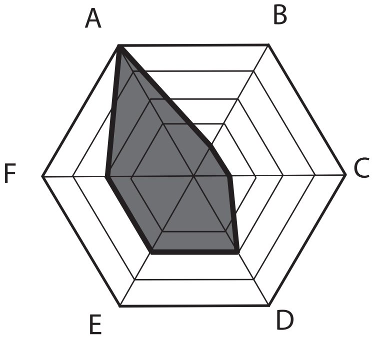

Figure 3. *The Engelbrecht-Harding radar diagram representing the degree of onlineness of the web courses described in this paper*

solutions and previous exams with solutions are also available from these web-pages. But lecture notes are also available in hard copy form.

Dimension E – *Richness* – the web-site contains graphics and video-clips and there is more than just text communication on the web-site. But there is no CAS available on the site and no Java applets. About 90 percent of the videos consist of `whiteboard'' lectures, made using and interactive pen display (see the next section for technical details). The rest of the videos are screen-recorded animations and simulations made using software such as Scientific Workplace, Maple, Finite element programs, Fractal programs, Complex Analysis programs, PowerPoint, etc. We also present videos of events such as the collapse of Tacoma Narrow Bridge or videos illustrating the theory, for example a video showing the bending of actual beams and plates. The latter kind of videos are captured by a digital video camera and edited by the Windows Movie Maker (standard in Windows XP). All videos also contain sound.

Dimension F – *Independence from face-to-face contact* – is at a medium level: there are daily face-to-face meetings between teachers and students in the first two weeks, and optional access to teachers during the subsequent two weeks of study.

In the next section we give some more details concerned with dimension E, i.e., the technology – hardware and software – used in the courses.

Hardware used for making the video lectures

In 2000, the first author started to investigate the type of tools that could be used for the purpose of making video lectures in the easiest way possible. An important requirement was that these utilities should include, but not be limited by, the possibility to record activities similar to classical blackboard activities and, of course, simultaneously record the voice of the lecturer. There are several reasons for this strict requirement. He felt that he can do better teaching with a blackboard at his disposal, where he can write mathematical symbols, make illustrations, etc., while he is explaining. In fact, many mathematicians feel handicapped if they are limited by e.g. PowerPoint presentations that have to be prepared ahead of time (this view is consistent with the findings of Misfeld, 2006).

Several possibilities were considered. First a small Wacom Graphire[7] tablet was tried. This device is possibly the cheapest one available. However, one must follow the pen movement with one's eyes on the screen while writing on the tablet, and achieving readability and elegance requires quite a bit of training and concentration. The first lectures were made using this drawing-tool, in addition to drawing software, a simple microphone connected to the soundcard and software for recording the screen activities. Today he uses a much better (albeit much more

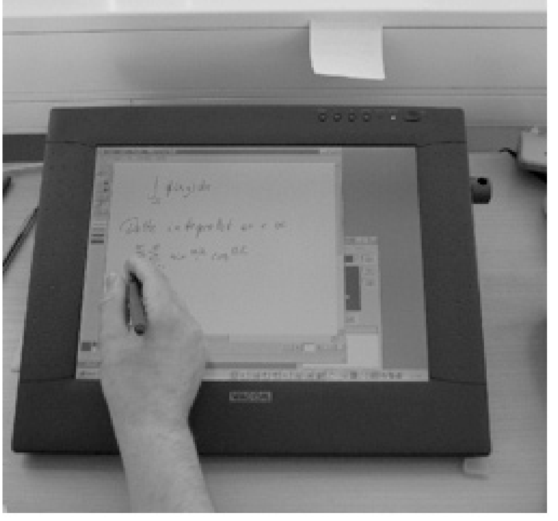

Figure 4. *An interactive pen display*

expensive) drawing-tool, namely Wacom's Cintiq 15x interactive pen display (see figure 4). All screen movements and the lecturer's voice are recorded (see an example in figure 5).

This tool combines the advantages of an LCD monitor with the controllability, comfort, and productivity of Wacom's cordless, tablet technology that needs no batteries for power supply. By working directly on the screen, one can navigate faster and more naturally. It allows one to adjust the inclination of the screen to one's liking. The additional hardware needed includes headphones with a microphone, a PC (minimum 400 MHz, but the faster the better) with a good soundcard and a good graphic card (e.g. Gfors 2 or better). It is important that the correct graphic card drivers are installed properly. This is often forgotten (even by experts); for most purposes it doesn't matter, but it is essential in recording the screen. A typical signal that drivers are missing is that the mouse doesn't respond promptly while recording the screen. Had we known this at the beginning, we would have been spared many difficulties. In fact, for a long time we thought that our problem with discontinuous mouse-movements was due to the fact that our processor was not fast enough or that there was too little RAM. To reduce the problem we used to record only a modest portion of the screen, something which is comparable with writing on a very small blackboard.

In appendix 1 we offer some additional guidance concerning available screen recording software and techniques of using it.

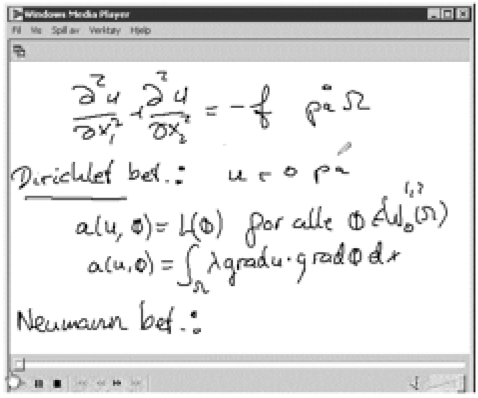

Figure 5. *Screen recorded video-lecture*

A project of evaluation of the courses

As stated earlier, this paper reports the first author's practical experience with the preparation and the teaching of the courses. In the aim of proposing some conjectures about the quality of the instruction in the web-courses (WB), compared with traditional face-to-face courses (FTF) and pointing to directions of future research, the third author asked the first author to respond to a questionnaire. The first author's responses have to be interpreted as his perceptions of his practice, not as an objective evaluation of this practice. These responses are based on his informal conversations with students and their results in the courses.

The questionnaire (reproduced in appendix 2) was inspired by the taxonomy for the design and evaluation of instruction proposed by Seidel et al. (2005). The taxonomy takes into account four categories of aspects of instruction: cognitive, psychomotor, affective and interpersonal. The first author – a professional mathematician, not a mathematics educator – agreed with most of the items. While these positive responses may not be very informative for the mathematics education researcher, other responses point to issues that would be considered serious by a mathematics educator and are therefore worthy of attention for the readers of this journal.

In particular, the response to the first item among those addressing cognitive aspects – "In WB students are more engaged in decision making than in FTF" – was, "I don't understand the question or the relevance to my mathematics courses". This response suggests that students in the web-courses do not participate in decisions about the content of the courses or forms of assessment. These are expository courses where students' task is to understand the mathematical content of the lectures and to apply this content in solving given tasks. Students are not engaged in projects where they would have the choice of the subjects of study and could construct mathematical models on their own. Mathematics educators would be likely to contest this attitude to mathematics teaching and learning. Research on reasons of high attrition rates in graduate (particularly doctoral) programs in mathematics in North America has shown that not including students as partners in decision making in courses and research may have a negative effect on their success and persistence towards the degree (Herzig, 2002). This discrepancy between mathematicians' and mathematics educators' points of view underscores the need of a closer cooperation between these two groups of researchers on the activity that is common to both, namely mathematics teaching.

Another response worthy of attention was, "I have no idea", to the second item in the 'Affective aspects' category, namely, "In WB students learn better to control their emotions than in FTF." From the point of view of an educator, affect is an important variable in mathematics learning and cannot be ignored in course planning and teaching (see e.g. Sierpinska, 2007; Sierpinska, Bobos & Knipping, in press).

Possible extension of the web-courses experience

The first two authors have been thinking of developing other web courses, particularly in teacher education programs and doctoral programs at their respective universities.

Web-courses in mathematics teacher education

The impression of success so far has encouraged the first two authors to extend the range of applications of the web-course concept. They are now preparing the implementation of the concept in an already developed web course in applied mathematics at Luleå University of Technology which is aimed at Swedish secondary mathematics teachers. This course has already been taught by the second author at the Department of Mathematics for more than a decade, but it will soon be possible to follow the whole course as a web-course. The course syllabus consists of an introduction to important subfields of applied mathematics. All parts of the course are available on the web[8].

The files posted on the web include animated gif-files (cf. Lecture 1, section 1; Lecture 2, section 6; or Lecture 3, examples 5 and 8). These files illustrate the theory (e.g. the mathematical theory of a ball rolling on a given surface). More information is available in (Byström & Persson, 2004). As a next step the first two authors aim to make video-lectures on these topics using the same technique as the one used at the Narvik University College. Moreover, the first two authors plan to incorporate suitable parts of the existing video material into this course. A further cooperation between Luleå University of Technology and Narvik University College concerning mathematical learning is particularly interesting since Narvik University College have started a training program for secondary mathematics teachers in August 2003.

Web-courses in the education of doctoral students

In 2002 parts of the video concept started to be used in connection with the joint doctoral program at the Narvik University College and the Luleå University of Technology. One example is that parts of the basic theory of homogenization (a subject in applied mathematics) is now available in the form of video-lectures on the web[9]. These lectures have been followed by doctoral students both in Luleå and in Narvik. Another example is that doctoral students have often taken oral exams using tablet and microphone in Narvik which was broadcasted via internet and at the same time recorded as a Windows media streaming file (on some occasions for up to 4 hours). In this way the censor in Luleå could follow the examination, either live or later on (if he or she was busy otherwise at the time of the examination) without having to travel to Narvik. A typical question is: Why don't we use the standard video-conference devices for this purpose? The answer is that this way we save a lot of time and effort since we needn't make bookings or appointments and arrange activities which involve several members of the technical and administrative staff at both places. Moreover, no expenses are involved, which is a very important aspect. This way the involved professors can spend all available time to help and advise the students.

The above described course for mathematics teachers has also been used as a very popular basic course in applied mathematics for PhD students in other subjects. So far, more than 400 PhD students from approximately 35 different subjects have participated in the course (mostly from Luleå University of Technology and Uppsala University). In particular, approximately 10 PhD students in mathematics education have taken this web-based course. Moreover, this way of approach in teaching has been one of the most important ingredients when developing the special model for education of doctoral students and guidance of supervisors in research groups, which is now, sometimes, called the Luleå model (see Grevholm, Persson & Wall, 2005).

Final comments and concluding remarks

There are several interesting advantages of the described screen recorded video-lectures. A video-lecture can be better than an ordinary lecture since the teacher has the possibility to redo parts of the lecture until he or she is satisfied with it. Moreover, the teacher may use more of his/her time to supervise the students individually and give more feedback on the learning process. The students have the possibility to follow the lectures at their own pace and watch them as many times as they want and at times and places most convenient for them. This has also turned out to be very useful for those who want to combine work and study or don't want to move away from the place where they live. In ordinary classrooms students usually prefer a break after one hour of listening to a lecture. It is interesting to note that they usually don't take similar breaks when they are watching video-lectures. This indicates that the students get less tired watching video-lectures than ordinary lectures. Moreover, after introducing this new teaching-method, the grades have improved. Questionnaires passed on to students at the end of each course have shown that most students like this new way of learning.

It is perhaps worth mentioning that the experience with web courses described here can be considered as a response to the challenges of technology in mathematics teaching at the university level, raised, in 1993–94, by a large investigation conducted by the *Swedish agency for higher education* (Högskoleverket, 1999).

Surely, more systematic research is needed to probe whether the first two authors' confidence that the web courses produce better learning is indeed justified. More information is needed on what is actually happening on the cognitive, affective and other planes of teaching and learning in these courses.

Without knowing and understanding these aspects of the courses, the experience will not be reproducible. Like many other teaching innovations, the courses might work well when taught by their authors, who constantly make adjustments and modifications 'on the go', taking into account the situations at hand. But the innovators are not always able to make these necessary adjustments explicit and communicate them to others. Another teacher, knowing only the superficial and technical aspects of the project, could believe that these aspects are the only relevant variables which should guarantee the success of the project. But the technical aspects of teaching do not guarantee success. This phenomenon has been described by Brousseau (1997, p. 37) as the Dienes effect. It explains why teaching experiments, which work when conducted by committed teachers-researchers, fail when the material conditions of the teaching are reproduced but the teacher only follows prescribed lesson plans, without feeling responsible for the results. Material conditions are relatively easy to reproduce (although they sometimes require costly equipment, as is the case of web courses described in this paper), but these conditions alone do not guarantee the reproduction of mathematical meanings and students' understanding (see Artigue, 1992, p. 57, for the distinction between *external* and *internal* reproducibility).

This is not to say that the material conditions are irrelevant. They may be necessary for the success of a teaching approach, but they are not sufficient. Technology used in the web courses must function well and its use must save time, not waste it. But suppose it works well; what other factors are responsible for the success of the approach in terms of the quality of students' learning? One has to look at the many variables at work here: e.g., the ways different teachers use the technology; their communication styles with students; tasks given to students; students' learning habits and work organization; methods of assessment and their impact on what is considered as the 'learning outcomes' by the teacher and the educational institution to which they are accountable.

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Notes

1 The courses are available free of charge on the web at ansatte.hin.no/dl/ka.html and ansatte.hin.no/dl/pde.html

2 http://www.fields.utoronto.ca/programs/mathed/task_forces/on-line/

3 http://econcordia.concordia.ca/en/html/

4 Some of the videos can be viewed under the header ”The Analysis Book 2003” at science.kennesaw.edu/~jlewin

5 http://videre.ntnu.no/pages/programs/delta_-_matematikk_fjernundervisning/

6 http://www.tekstud.com/

7 http://global.wacom.com

8 The files are accessible from http://www.sm.luth.se/~larserik/ (click on the link to ”webcourse in applied mathematics”).

9 ansatte.hin.no/dl/modmater/video.html

Appendix 1

There are several programs on the market for recording screen activities. Here are some examples:

- Hypercam by Hyperionics. The web address is www.hyperionics.com
- Camtasia Recorder and Camtasia Producer by TechSmith. The web address is www.techsmith.com
- ScreenCorder 3 by Matchware. The web address is www.matchware.net
- Windows Media Encoder 7.1 (free software) The web address is www.microsoft.com/windows/windowsmedia/forpros/encoder/default.mspx

Before we start describing these programs, we want to add that we have personal experience with ScreenCorder and Windows Media Encoder only. Information concerning the two other products can be found on the internet or from our contacts with persons who have significant experience in this field.

Many users consider Hypercam as one with fewest features among the four. It also places the greatest demands upon the computer. While recording with Hypercam it has been reported that some computers work sluggishly and that the mouse doesn’t respond promptly. It also cannot record the picture of more than a modest portion of the screen or else a message appears that there isn’t enough memory. The color depth has to be set to the minimum of 256 colors, otherwise the situation becomes impossible. Hypercam has no editing features although the company also sells another product that can edit the AVI files after they are made. Therefore, if one makes a movie with Hypercam one cannot make changes in the video afterwards. If one makes a mistake, one has to start over. The process of making a movie is normally a two-step process: 1. creating the basic material; 2. exporting it to the form one wants. Hypercam does these two jobs together. Hence the movie is ready once the recording is finished. This saves time. Windows Media Encoder, which, by the way, is free software, has the same advantage.

Screencorder and Camtasia Recorder both have to be exported to a file format, and this may take a long time, which, of course, depends on the size of the movie and how fast the computer is. Therefore, if one needs the movie right away, Windows Media Encoder or Hypercam are a better choice.

TechSmith is absolutely one of the leaders in the field of recording computer sessions. The Camtasia Producer allows one to edit the AVI files, to combine several files into a single movie and to remove unwanted material. In addition, it makes it possible to change the compression method by which the AVI file was made and to convert AVI files into files of other types, e.g. WMV (windows media files for streaming). It also enables the teacher to adjust the quality and size of the exported files to match the kind of internet connection speeds the students are likely to have. The Camtasia Producer has also a `Pack and Serve'' utility that allows one to make movies in EXE form which is supplied with a built-in Camtasia Player so that the student can be independent from the Media Player, the QuickTime or other players and all viewers will see exactly the same thing. Camtasia also allows one to set the movie to display on the full screen, and to repeat or to close its window automatically when it is done, and to start playing automatically or not. A disadvantage of the Camtasia Player is that it does not allow one to drag the cursor from place to place while the movie is playing.

The Camtasia Recorder and ScreenCorder 3 are very similar but there is a major difference. When recording with ScreenCorder 3, one has the option of pausing anytime and dragging the cursor back. By doing this, the recorder automatically over-writes anything that comes after the position to which the cursor has been dragged. This is a very good feature. Some people use both ScreenCorder 3 and Camtasia. They make movies on ScreenCorder 3 and then Camtasia to do the editing. A big disadvantage of ScreenCorder 3 is that it tends to be unstable on several computers (causing `crashing'' problems). More information on this problem can be found at the discussion forum at www.matchware.com

Many recording programs have problems with sound quality when exporting to WMV-format. For example when exporting to this format by ScreenCorder 3 the sound quality never gets better than 16 Kbits/s, 16 KHz, mono. This is usually not good enough. It is possible to solve this problem by first exporting to AVI, and then converting to WMV by using the Windows Media Encoder 7.1. This allows one to raise the quality of the sound as much as one wishes.

We usually use 126 Kbits/s, 44KHz, stereo. Our experience is that this is the lowest bit rate which gives perfect sound. Many of the video-lectures we use are even made using Windows Media Encoder 7.1 alone. Some reasons for this are:

- It is free of charge.
- It allows one to produce WMV-files directly (with perfect sound), i.e. it is possible to put the file on the internet immediately after having finished the lecture. This saves a lot of time. The sizes of the WMV-files are normally much smaller than any other format (at least when we record whiteboard writing on the screen).
- There are no length limitations (in fact we have made videos lasting more than 5 hours).
- It is possible to make live broadcast on the web and make a WMV copy of it and place it on internet immediately afterwards.

Starting with Windows Media Encoder 7.1 is absolutely the simplest and fastest way of making a video lecture. Still, many of our videos are made by ScreenCorder for the following reasons:

- When pausing in Windows Media Encoder the picture is frozen in about 5 sec (the sound is not). Therefore after taking a break in your lecture you have to find something to say which does not require any changes in the video until the screen movements are recordable. However, this is not a big problem.
- After pausing in Windows Media Encoder it is not possible to move back and start recording at an earlier stage.
- Very fast changes are not recommended in Windows Media Encoder, because it may be difficult to capture the movements. This is due to the fact that the computer is compressing and capturing at the same time. However, this is never a problem if one is only capturing fast mouse movements (e.g. writing or drawing).

Finally, we want to give some guidance concerning suitable file formats. What we are using as the final output is the WMV-format or asf-format (streaming windows media). One of the advantages with streaming media files is that the viewer can start watching the video at once without first having to download the entire file.

Another advantage is that when one uses the screen capture mode in e.g., Windows Media Encoder, it makes it possible to make really small video files. The smallest video file we have made (with perfect pictures, motion and understandable voice) has a bit rate as low as 8 Kbits/sec. For those who are unfamiliar with this terminology we just mention, for the sake of comparison, that it is possible to transmit at least 30–40 Kbits/sec through any telephone connection. Many of our screen recording videos have a bit rate less than 60 Kbits/sec, and, in most of these videos, only a rate of 3 Kbits/sec is necessary for showing the video-motion. Thus, increasing the bit rate will only help improving the sound quality.

Lately, we have started to use as much as 129 Kbits/sec for the sound (stereo-CD-quality), since most students have a broadband internet connection. Previously, it was impossible to edit WMV-files, but after the release of the program Windows Movie Maker (standard in Windows XP), this is now possible. It should be noted that also with this software stability problems have been reported on the internet. Moreover, our experience is that it is often easier and faster to record a new video than editing the old one, particularly if it is short. For this reason, many of our videos are no longer than 5 minutes.

Appendix 2

Cognitive aspects

1. In WB students are more engaged in decision making than in FTF.
2. In WB students are more engaged in problem solving than in FTF.
3. In WB students are more engaged in logical thinking than in FTF.
4. In WB students are more engaged in critical thinking than in FTF.

Psychomotor aspects
1. In WB students are more perceptually and physically active than in FTF.
2. In WB students have more opportunities for practice than in FTF.
3. In WB students have more opportunities for developing their own thinking, reasoning and problem solving strategies than in FTF.

Affective aspects
1. In WB students develop a more positive attitude to mathematics than in FTF.
2. In WB students learn better to control their emotions than in FTF.
3. In WB students are more attentive in following the lecture than in FTF.
4. In WB students develop less narrow beliefs about mathematics solving than in FTF.
5. In WB students have a higher sense of agency relative to mathematics than in FTF (i.e., they are less likely to say, `I need the teacher to tell me if I am right or wrong'').

Interpersonal aspects
1. WB favours more mathematically meaningful interactions between students than FTF.
2. In WB students obtain a more rapid feedback from the teacher about their thinking and solutions than in FTF.
3. In WB the teacher-students relationship is less hierarchical and based more on a partnership in a common endeavour than in FTF.

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Sammendrag

I denne artikkelen beskrives og diskuteres to master-kurser som er basert på videoopptak av PC-skjerm. Disse kursene har blitt fulgt av sivilingeniørstudenter ved Høgskolen i Narvik siden 2001. Ett antall andre kurser, som finns tilgjengelig, blir diskutert og sammenliknes med vårt konsept. Kurserne evalueres ut i fra en matematikkdidaktisk synsvinkel. Vi mener at vårt konsept inneholder både tekniske løsninger, personliga positive erfarenheter og didaktiske ideer (for eksempel vedrørende fysisk nærvær av lærere/veiledere i tillegg til videoundervisning) som utgjør et interessant emne for matematikkdidaktisk forskning.