MATHEMATICS TEACHING ON THE WEB FOR STUDENT TEACHERS: ACTION RESEARCH IN PRACTICE

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The article summarises experiences gained through my practice as web-based pedagogue in mathematics at the University of Nordland (Norway)'s teacher-training institute. It has been my wish to make continuous improvements to my practice and I present two of the most important improvements that I investigated on the basis of practical action research. Data collected from student interviews indicates that video lectures produced by filming whiteboard teaching yields a greater educational result than so-called screen video of a slideshow run on a PC. In addition, we present and discuss significant findings regarding the use of Skype in web-based teaching.

INTRODUCTION

The purpose of this article is twofold. Firstly, I wish to describe some of my findings in respect of the new web-based maths teaching in the teacher education at the University of Nordland. I then wish to present some suggestions for possible initiatives against the background of empirical observations collected during my first term of web-based teaching.

My professional background is as university lecturer in mathematics. During the spring term 2011 I taught the first class of student teachers at the University of Nordland in statistical analysis, basic geometry and probability calculation in a web-based version. In addition to the web-based classes, this teaching has been held in equivalent classes on campus. The goal of the web-based programme is to enable a flexible form of tuition in which the bulk of the teaching per se is conducted over the internet instead of face to face, as was the case in the old general teacher-training programme. One of the primary intentions is that the university to a greater extent should accommodate the students' desire for freedom from a teaching form that entails constraints on time and place. Traditional campus-based tuition forces the student to be present at the time and place in which lectures and group seminars are held. By putting lectures out as video clips on an established web address, as well as arranging web-based meetings with voice and webcam, an attempt has been made to liberate participants from location-bound tuition. The video clips are accessible 24 hours a day so that the student in principle can view them whenever it is convenient and on any suitable medium that has a modern web browser installed. The idea is that this provides far more students with an opportunity to complete teacher training – primarily those who for one reason or another are unable to move to Bodø during the period of study.

I believe that it may be of interest to others who are involved with web-based tuition in general, and web-based maths teaching in particular, that I share these experiences.

Issue to be examined

In the course of this article I will address the following questions, without arriving at definitive answers. What do student teachers in mathematics need from a web-based training programme? On what terms should it be based? How can modern ICT aids contribute to building up a learning fellowship amongst web students, along the lines that campus students gain from their joint presence?

THEORY AND METHOD

Theoretical basis

What makes action research attractive as a theoretical backdrop for the survey is that it gives the researcher a more participatory role in their own research. It is not only permitted but even encouraged to be both a participant in the experiment that is being carried out as well as to carry out research on it. The expression “experiment with" rather than “experiment upon” can be an expression of the general philosophy behind this scientific theory (Schmuck, 1997). The criticism often expressed by traditionalists is that such an approach will produce problems in terms of repeatability and objectivity. It may be replied that even with a traditional socio-scientific approach it is often impossible to guarantee an adequate degree of objectivity. The results that are presented are often derived from issues and interpretations of results that are not necessarily repeatable. One can also view action research as a systematic means of describing or interpreting personal interaction with the practice field, often entailing a quest for “improvements” after one or more actions have been carried out.

In the methodology section of this article we will look more closely at our own approach to this general way of viewing action research. In particular we will attempt to employ it to challenge our own practices within web-based pedagogy.

The concept of web-based pedagogy

Web-based pedagogy can be viewed as one of the building blocks in a web-based education, in which the pedagogic interaction between teacher and student takes place via a data network as opposed to by face-to-face contact in a teaching room. The term “web-based teaching” can perhaps be understood as a more general concept of which the actual web pedagogy forms one of the parts, alongside other elements such as how the courses are adapted to the internet, which attendance requirements should be for a web student as opposed to a campus student, etc. In this study I will deal particularly with changes in the means I have employed to present material via the internet.

Maths teaching for student teachers

For student teachers one wishes especially to promote a type of mathematics of a more practice-related and didactic variety than is found in other higher education. Teacher training is primarily a professional study that should be firmly rooted in practice and an attempt is made to design a type of maths teaching that combines the purely theoretical aspects with didactic interpretations of material. How can

mathematical connections form a didactic backdrop for a teaching programme? Different teaching theories, amongst which social constructivism is perhaps most prominent today, should shine through in the teaching.

Method

In this article I have chosen to employ a responsive action research form in which I collect data in advance of the actions in order to be able to form an instantaneous picture of how my own practice is working. This forms a basis on which to determine adequate measures, often with contributions from others such as the year coordinator and colleagues. These dialogues with parties outside the pedagogic interaction with the students formed a shift in perspective, otherwise known as the establishment of a meta-position (Stensland, 2005). These had a central role in the assessment stage in terms of making decisions about which initiatives to include in the action.

All in all, I have adapted the familiar action-research cycle to my own research in the following manner:

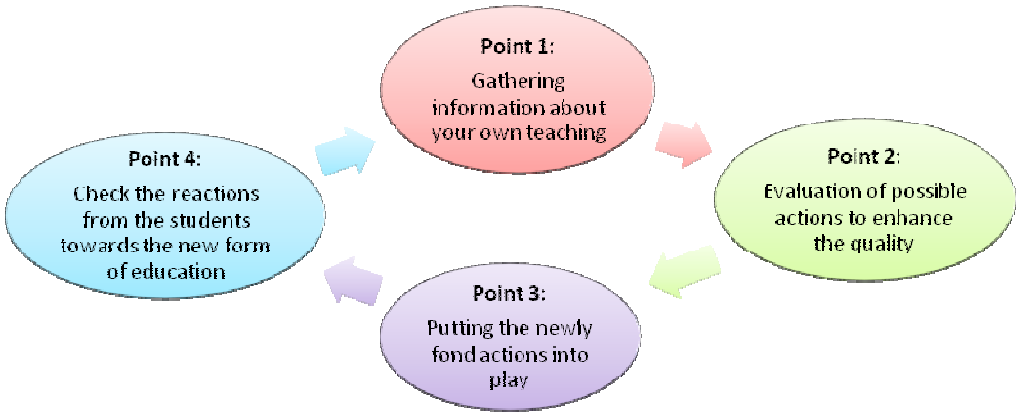


Table 1: Action-research cycle in personal teaching practices

The purpose of action research

The concept of web-based education contains, naturally, no detailed definition of how the pedagogic scheme should function with regard to each individual course. It is naturally up to each individual web tutor to find his preferred way of doing this, according to the available resources and the terms of reference that are set by administrators, the director of studies and others. The goal is defined in just such terms: a search for the form or forms of web-pedagogic mathematics programme that provides the best possible learning outcome for student teachers.

Actions

The actual actions will be dealt with in point 3, where I employ the new teaching reform. I have chosen to highlight two actions in particular, even though I undertook many minor adjustments to the teaching programme which will not be described here:

1. Turning from static slide-show-based teaching to filming whiteboard presentations.
2. Using Skype for assistance in solving mathematical tasks.

In addition to these primary actions I constantly made small adjustments involving, for instance, the use of technical aids and how the material was presented.

Data in the survey

Data collection is built on concrete responses from students regarding how they perceived the different teaching forms used in the courses that I held. In addition we have attempted to be responsive to student suggestions and we may well say that the most important action has been a refined and interpreted version of these.

Description of electronic aids

To understand the pedagogic context in which the web study has been carried out we have chosen to include a presentation of the technical environments that were tested during this one term, as well as some lessons drawn from their use. This is in order to understand more easily the backdrop for the chosen actions. In terms of action research this description will be involved in points 1 and 2 described in Figure 1: Action-research cycle in personal teaching practices .

Camptasia Studio is a computer programme that provides the teacher with the opportunity to combine a Power Point slideshow with sound/video of the lecturer which can be edited and put out on the internet for the students. Many lecturers at the University of Nordland, including myself, use this program to record lectures which in turn usually is uploaded on the virtual learing environment (VLE) “Fronter”.

Fronter is the VLE used by all students and staff at the Faculty of Professional Studies in the University of Nordland at Bodø. The platform offers a common structure with functionality for document sharing, news wheel, submissions and forum. As much of the teaching in a web and practice-based study is carried out over the internet, Fronter is the most natural portal for making teaching material accessible.

In addition to the purely static one-way communication involved in Fronter, we have also attempted to persuade the students to use the forum in Fronter for presenting their questions. In practice, however, it was difficult to motivate students to use the specially-designed forums to any great extent. We have not had time to investigate the reasons for this, but we see that one of the reasons is that it takes “many clicks” to find out whether there is any activity in a particular forum. We believe that a learning portal such as Fronter must incorporate means of notification such as email, RSS and Facebook. In addition, editing of mathematical text must soon be taken seriously in such portals. At the moment, only poor-quality formula editors are available. In addition, support for LaTeX should be investigated in order to simplify

entering formulae without having to resort to massive clicking in a Word-like WYSIWIG (”What You See Is What You Get”) editor.

At present, *GeoGebra* is the major digital learning platform in fields such as analysis and geometry in secondary schools, sixth-forms and parts of higher education.

The use of GeoGebra provides web teachers with many opportunities to demonstrate principles and analysis within geometry and function teaching. We used GeoGebra to demonstrate theorems such as Thale’s proposition by making screencasts in Camptasia Studio together with voice recording. The screencast combined with GeoGebra provides an opportunity to make dynamic geometric constructions, something that is not possible to put directly into Power Point without inserting film clips. In addition, the constructions are very precise and it is possible to demonstrate to the students how this important learning resource can be used.

As an extension of this it is possible to imagine the use of this tool in internet meetings, if it were possible to share one’s own desktop with the students. If concrete problems are brought up in which the students are struggling in geometry, solutions for these can be shown very effectively to everyone in the internet meeting by demonstrating the construction live, with everyone following. In this way one can attain a virtual blackboard teaching in geometry. Conferencing programmes such as Skype offer just such a system of sharing the desktop that can make this possible.

NTR NetMeeting was used on a couple of occasions and offers the opportunity to plan an internet meeting with several students in a group. It is generally only the teacher that has the opportunity to arrange such a meeting, so planning should be done well in advance. The student body can be called in for the meeting by email. NTR NetMeeting supports both sound, image and text, but in terms of quality the service was not very satisfactory. A significant delay was apparent in the sound and the picture was significantly sub-standard. For holding internet meetings it would be better to look at alternative services such as Adobe Connect and Skype.

Skype is a type of computer programme that enables real-time communication in speech, text and image. If logged in, contact between different participants in a learning community can occur spontaneously. The service is free of charge, apart from the conference section.

This programme is particularly straightforward to use in a web-based teaching context as it is not necessary to keep attention on the programme itself all the time, as is the case for instance when using a chat function in a web browser, because when someone wishes to take contact, the user’s attention is drawn by means of sound/notification.

It will always be the case that direct exchange of opinion and joint problem solving in mathematics will be a fairly central part of maths teaching. The discipline is so abstract that students can quickly find themselves frustrated by “getting stuck” in their own understanding of it. Regular contact with other students and with the

teacher can be regarded as an essential part of mathematics study. Skype can be a good alternative in this respect since it is easy to contact other students and teachers who are online in order to get help.

Finding: it was observed that individual students who did not often speak out in a normal classroom situation found it easier to do so when using Skype. Email may also seem more formal than Skype, which assumes a more chat-like form.

RESULTS AND DISCUSSION

Student reactions after two months of internet tuition in Camptasia

Between the two meetings of the NP class a period of eleven weeks elapsed. During that period, new lectures and teaching on statistical methodology recorded with the help of Camptasia Studio were regularly issued, along with accompanying assignments and guidance with the help of NTR Meeting. The whole statistical analysis syllabus was gone through before the first meeting and we were very anxious to hear the students' reactions. Up until then there had been a more or less one-way pedagogic transmission of the syllabus.

The first hour with the group after the meeting was used for a repetition of the greater part of the syllabus that had been gone through on the internet. After this session we received feedback such as "I learned more during these two hours with you and the blackboard than by watching all the online lectures combined".

Why was this the case? A great deal of time had been spent in making an entire lecture series on statistical methods, in which emphasis was placed on using illustrations to simplify understanding of the fundamental concepts. The slideshow on which the online lectures were based was also made available so that the students could look at it in their own time as well as watching the actual video, optionally pausing/stopping/rewinding it.

The students pointed out that the material had too high a threshold to be put out on the internet. Analytical statistics was a topic of which few of them had any experience in advance and it required a good deal of assimilation time to understand all the new concepts that were introduced during the course. The students also pointed out that they had few "pegs to hang the material on". The perception of having learned a great deal during the blackboard teaching could well have been the result of a subconscious maturing that had taken place in the period leading up to the meeting.

In addition to the material on statistical analysis we had also put out some lectures on geometry. For these, films of demonstrations, prepared with GeoGebra on an office PC, were used, with an explanatory voice recorded in parallel. These lectures were given a better reception. Reactions received suggested that "the only thing we managed to follow was the practical material on GeoGebra, because then we could see things done step by step".

Another issue highlighted in student feedback was that one had been too little accessible as teacher. The communication was too much in one direction and the sessions using NTR Meeting were only partially successful: the sound/picture was too poor and the use of time too little flexible.

Planning a new teaching form

Some hints had also been given during the course that the chosen teaching pattern was not entirely suited to the fairly heavy statistics material. We reviewed some web-based lectures that were produced by another institution (NKI) which combined filming of blackboard-based lectures, simple statistical attempts and slides. Short and simple lectures that demonstrated with actions and words what the statistical formulae entailed. Even though the material's level of difficulty was far lower (descriptive statistics) and filming the lectures demanded a great deal of preparation and resources, there were ideas to be gained here. It seemed rather alarming that one required a cameraman to actively zoom in on formulas written up on the board, as well as that the final result contained edited-in film clips from other presentations of the material. The resources demanded by this type of arrangement clearly exceeded those available to me.

We were however interested in how others had designed web-based teaching in mathematics and conducted internet searches about this. I then found via YouTube a commercial resource from the American firm Classmate. This showed how a teacher, just through filming a static section of a whiteboard, was able to show mathematical procedures in a very understandable manner. I had the idea to try out the same thing. With a film camera mounted on a tripod I found out that this was possible without the help of an assistant, in other words, with far less planning and use of resources.

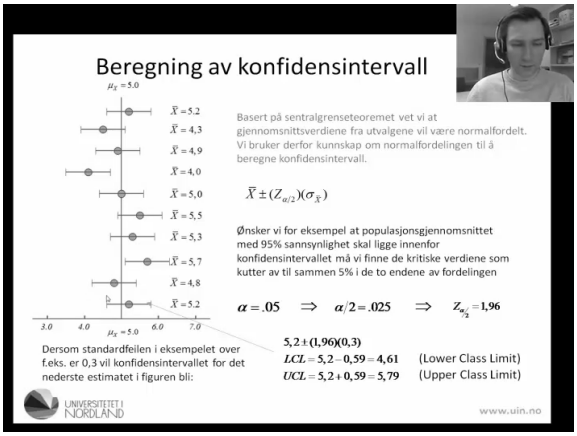
In order to accommodate the students over the second issue – a greater degree of presence – we decided to begin to use Skype far more actively. Skype has the opportunity to publicise accessibility by setting one's status in the programme. If actively used, this can give an efficient way for students to know about your virtual availability for consultation.

The actions themselves

Having completed the whole syllabus before and during the final session, we only had the repetition lectures to try out the new lecture form. When the camera and external microphone were rigged up it was possible to concentrate fully on just the pedagogic conduct of the lecture. Personally I found this much simpler as a teaching method than using Camptasia. The reason for this may be that the teaching took place in a more familiar context, in front of a board.

In addition, as intended, we set up the use of Skype. Accessibility was ensured on the occasions when it was possible to help the students with problem solving. This led to a number of enquiries, either in the form of groups of students taking contact or of individual contact.

Student reactions to the actions, as well as follow-up assessments



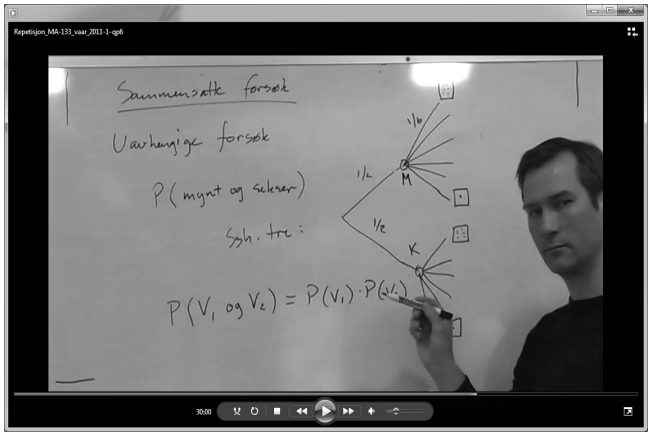


Figure 4: Web-lecture before and after the action. On the left the Camptasia studio recording, on the right, filming my own lecture.

Following the one repetition lecture that we had time to hold for the students we got in touch to ask for reactions to the new lecture form. We asked the students to draw a comparison between the previous form, with the Power Point presentation, and the new filming of the blackboard-based teaching. We did not use a questionnaire but instead sent out an email to which all the web-based students were asked to respond. The text was as follows:

> I am working on writing up the web-pedagogic concepts of NP 5-10, and in this connection wonder whether I could have your opinion about the new form of web lecture, involving filming of the whiteboard, which I demonstrated in the last repetition lecture. Your opinions can contribute to shaping the future layout of the maths teaching in the NP classes. Are there other things that you feel could improve the web-pedagogy?

In all, the email was sent to ten internet students who had followed the course. I received seven replies. The reactions were unanimously positive. One of the students says:

> Hi Helge! The last web lecture with the whiteboard worked well (…) I believe at any rate that this method of conducting web-based teaching is better than Powerpoint lectures (…) I think, by the way, that the sessions in which you used geogebra were very good. The fixed times on Skype are a good idea.

Another wrote:

> Hi Helge! I liked the whiteboard presentation a great deal and would be very glad to have this type of web-based lecture in future. It becomes immediately easier to grasp and one gets concrete examples for comparison.

Skype also worked very well in the sessions we had with the students. To begin with it was feared that there would be altogether too many enquiries, but it seemed as though the students prepared their questions well before they took the step of contacting me.

We believe that using Skype creates a more synchronised presence on the net. The dynamic contact list with availability status creates a proximity to the student that is not achieved to the same extent via more asynchronous media such as Fronter.

Justification in mathematics-didactics research

Raymond Duval has researched the characteristics of the cognitive processes on which a good learning process in mathematics is based. In his article "A cognitive analysis of problems of comprehension in a learning of mathematics" (Duval, 2006) he highlights the term "transformations between representations". In terms of mathematical objects, it is important for learning at least at achieve two types of cognitive representations of these. Within geometry, the one will representation will consist of the purely figurative representation (a right-angled triangle, for instance) and the other will consist of how these aspects are connected in purely mathematical terms (the theory of Pythagoras, for instance). Duval believes that the essential prerequisite for learning is the transformation between these systems; in other words, to understand a mathematical object the purely formal symbolic representation is not sufficient but must be supplemented by a an understanding of how the object is significant in other contexts. The more such representations of an object it is possible to form a relationship with, the better the result will probably be.

In terms of the transformation between these representations, it will be much easier to represent these by using a dynamic learning platform. If we take a blackboard/whiteboard as an example, it is easy to sketch the connections, draw a graph, make a diagram, etc to illustrate how a mathematical object will behave in different circumstances. In a lecture together with students – in which the lecturer has the opportunity for an active dialogue while lecturing – this principle will attain a higher dimension when an experienced maths teacher "here and now" can draw on different aspects or representations in accordance with how the dialogue is progressing. When it comes to internet lectures, this interactive element is naturally absent and we have to rely on presenting the material in a monologue style.

SUMMARY AND SUBSEQUENT EXPERIENCES

On the basis of student feedback we can gain an indication that the action led to a clear improvement of my own web pedagogy. Naturally, critical comments are possible in relation to such a conclusion. For instance, there may arise a more or less conscious desire to appear positive towards me in order to increase their chances of a better grade at the end of the course. Another critical comment to the final result may be that the nature of the actions themselves leads to a positive attitude:

- Modern humans often have a positive image of change, at least in areas in which problems exist. The saying "in need of a change" is a significant one.
- The simple fact that one has attempted to address a problem may in itself be enough to ensure that the students have a positive reaction.

Even if purely objectively we cannot say that this sort of change in web pedagogy will lead to a significantly improved learning process, it is possible, on the basis both of a theoretical consideration of maths learning (Duval, 2006) and of the unanimously positive public response, to assume that ground has been gained.

Subsequent experience

After this research was carried out we have been involved in several web-pedagogic designs of maths courses in connection with teacher-training courses at the University of Nordland. In general, experience has showed that predicting what is going to work best at specific student groups and syllabuses is no small matter. An experienced net pedagogue should probably vary the tools/media used according to the context at hand. As an example: A large proportion of the student mass in the subsequent courses was busy with full-time work in addition to studies and therefore had little time to receive guidance during working hours. It was quite simply necessary to study in the evenings, which meant that my online contact facility via Skype was of little significance. It was often the case that little work was carried out between meetings and that there was a rush of work immediately before the students came to meetings. To counteract this, obligatory web meeting can be used between the physical gatherings.

It has recently emerged that internet resources such as Khan Academy are very popular amongst students who have good English-language skills. These sites show videos in which the lecturers are more or less well prepared, but perhaps the informal tone is part of the attraction when two-way communication is difficult? Our experiences within web pedagogy is that this learning arena is rich in opportunities but that it is easy to be surprised about what works best when abstract mathematical concepts are to be communicated.

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