TEACHING AND TEACHERS’ COMPETENCE WITH ICT IN MATHEMATICS IN A COMMUNITY OF INQUIRY

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In the ICTML project the aim is to develop both mathematics teaching and the teachers’ competence with ICT and to perform research on all parts of the work. The research was situated in a social cultural framework. Teachers and didacticians worked together in learning communities inquiring into approaches for teaching and how computer tools can support inquiry in both teachers and pupils work. In this connection workshops at the university college played an important part. In this paper I will report from cases of workshops and how ideas for implementing teaching with ICT were developed and discussed in the learning community.

BACKGROUND AND RATIONALE

Implementing use of ICT (Information and Communication Technology) into mathematics teaching has been a slow process. In spite of huge efforts from the Norwegian educational authorities, the use of ICT tools is still rather weak in most schools (Erstad, Kløvstad, Kristiansen, & Søbye, 2005). A lot has been achieved with general use of computers, but less in specific subjects. Hardly any activity was reported in an evaluation of teachers’ implementation of the curriculum (Alseth, Breiteig, & Brekke, 2003). In my own experience, many teachers lack knowledge of how to utilise ICT tools in mathematics teaching and express need to see good examples and learn more about ways of using ICT. In the Norwegian curriculum plan, in effect from 2006, there is a demand to use “digital tools” in every school subject and specific demands are given in the plan for mathematics (KD, 2006).

The project ICT and mathematics learning (ICTML) aims to meet the challenge of investigating how ICT tools can be utilised in school mathematics and in particular how ICT can support inquiry approaches in teaching and learning. ICTML is both a development and research project, where teachers and didacticians, i.e. researchers and doctoral students at the university college, work closely together. Furthermore, the project has a close collaboration with another project, Learning Communities in mathematics, (LCM) (Jaworski, 2005), with fundamentally a common theoretical framework. Both projects are supported by The Research Council of Norway

I think of ICT tools in this context as computer software that is open and flexible not tied to specific topics or limited to pre-designed tasks. Such software provides ways of representing mathematical objects and relations and makes it possible to work on the representations. Thus ICT tools make it possible to investigate and experiment with mathematical ideas, discover patterns and relations and be stimulated in

mathematical thinking. In the project we mainly use spreadsheet, dynamic geometry and graph plotting program, and to some extent we use the Internet.

The research presented in this paper is concerned with how teachers and didacticians work together in workshops in the project and how teaching ideas and teachers’ competence develop. What kind of teaching ideas were explored in the workshops? What kinds of questions were raised in the discussions? Can we find evidence of inquiry in the workshops which suggest learning is taking place? An important question is if we can see inquiry approaches to teaching emerging from the workshops.

THEORETICAL FRAMEWORK

The research and developmental work in the project is situated in a sociocultural framework with the ideas of learning community and inquiry as key concepts. The idea of learning community builds on and extends Wenger’s concept community of practice (Wenger, 1998) with three modes of belonging, engagement, imagination and critical alignment as key concepts (Jaworski, 2006). The participants engage in the project activities at the university college and in schools, and develop ideas through imagination and critically align themselves with the project community by discussion and testing out ideas, and developing understanding of key concepts and the goal for the project. Furthermore, to practice inquiry is key concept in developing the learning community into an inquiry community.

Inquiry means to ask questions, investigate, acquire information, or search for knowledge. An attitude characterised by willingness to wonder, seek to understand by collaborating with others implies being active in dialogic inquiry (Wells, 2001). In the ICTML project as well as for LCM, an aim is for the participants in the projects to develop further into “inquiry as a way of being” which implies an attitude of asking questions, investigating and exploring – making inquiries into all levels in the project. This implies inquiry into mathematics, into mathematics learning and how mathematics can be represented and worked on with ICT tools.

The way ICT is used and implemented in teaching can be characterised by viewing the ICT tool as an amplifier or a reorganiser (Pea, 1987; Dörfler, 1993). The amplifier metaphor means doing the same as before, more efficiently but not fundamentally changing the objects and tasks we work on, whereas seeing ICT tools as reorganisers implies fundamental changes in objects to work on, and the way we work. For example in using a graph plotting program as an amplifier the software produces quickly the graph as the end product, whereas seen as a reorganiser the function graph itself is seen as a new object which can be manipulated either directly or by setting parameters. Use of tools as reorganiser implies a move from doing towards planning with implies work on metalevel. In a spreadsheet for example, a model can be implemented and later used for investigation trying various numbers. The calculations are left to the spreadsheet whereas the user needs to plan the model and set up connections between cells. In order to fully utilise the potential of ICT tools
such reorganising should according to Dörfler (1993), be intended and encouraged. This implies new kind of tasks and approaches to mathematics. Reorganising of cognitive processes can be seen when learners interaction with technology qualitatively transform their thinking (Goos, Galbraith, Renshaw, & Geiger, 2003). The ICT tools are not passive neutral objects, but can according to Goos et al, re-shape interactions between teachers, students and technology itself.

The view of ICT tools as potential reorganisers has implications for how teaching is planned and carried through. There is need for new approaches to the work, new tasks and problems for the students to work on and perhaps new ways of working together. This can be achieved by an inquiry approach towards ICT tools, mathematics and how mathematics can be represented and worked on with the ICT tools. An inquiry attitude opens up possibility for teachers and didacticians not to know all the answers and to engage when new questions and problems arise. Teaching in this context is seen as a learning process; through inquiring into the various activities, mathematics and use of ICT, and as teaching is planned and carried through, this implies learning through the activities (Jaworski, 2006). This will be part of the development work and research in the project with the aim to meet the challenge of reorganising tasks, problems and approaches to teaching.

THE ICTML PROJECT - KEY ACTIVITIES

Four schools take part in the project and three of them also participate in the LCM project. At the start of the project in each school teachers worked together in school teams discussing teaching ideas, developing teaching and supporting each other.

The ICTML project aims to support implementation of ICT in mathematics in schools guided by an inquiry approach to teaching and learning. By asking questions, investigating and experimenting with mathematical concepts and relations the learner, whether a student, a teacher or a didactician, develops knowledge and insight in the subject area. For this we need to use ICT tools that afford this kind of activity. Inquiry on all levels of the work is crucial to the project. In the LCM project, we inquire into mathematics, into teaching mathematics and how to develop mathematics teaching (Jaworski, 2005) – and additionally for ICTML particularly we inquire into the use of ICT tools connected to all these levels.

The software itself does not create inquiry, but the way it is used, the kind of tasks and how they are presented can be crucial. For this reason design of tasks and teaching approaches are important. The design cycle can be seen as guideline for the work – to plan, act, observe, reflect and feedback to future planning (Jaworski, 2007). The teacher teams in the schools, perhaps together with a didactician, plan lessons and carry through the plan in their classes. The lessons can be observed by colleagues or didacticians and reflected over in school meetings. Feedback can be provided from this discussion or otherwise by looking at video recordings. Then another cycle can follow, revising the plan or following up by extending the teaching plan.
A team of 12 didacticians in the LCM and ICTML projects work together to develop the projects including planning for workshops and research. Two didacticians have their work dedicated to ICTML, and additionally an experienced teacher, Otto, is employed part time to support development in schools and contribute to the workshops. In addition several colleagues from the LCM project also takes part in the ICTML workshops and contribute to building the community.

At the workshops for ICTML we usually start with a session in the computer lab. The workshop will often start with some short introduction to features of the software to work on, presenting tasks or teaching ideas as examples of use. Then teachers and didacticians work in pairs or small groups on suggested tasks, investigating further ideas or inventing new applications of the software. After a short break with some refreshments, results from the work in the computer lab are brought up on a large screen, presented and discussed together with further ideas and various ways of approaching the problems. In some cases we also have reports from teachers’ experiences and innovative work from their classes.

The intention is that experiences or discussions in the workshops should initiate further work in the classes. We can see the workshops as providing both competence developments for the teachers on inquiry using ICT tools and as a start of planning for teaching. In the project we see the workshops as an important activity in stimulating further development and building the inquiry community.

**METHODOLOGY**

The research methodology is closely connected to development in the project with the design cycle giving a framework for the activity. The research can be characterised as developmental and have roots in various other recent research methodologies, like action research, design research, learning study, lesson study (Jaworski, 2004). As the design cycle provides a model for the development it could also be characterised as a developmental cycle. Teachers are included as partners in the research, taking part in discussions and to some extent engaging in observations in classrooms with their colleagues; noticing issues that arise in the work and reflecting on experiences in the classrooms. The intention is that research in schools take place in close cooperation between teachers and didacticians.

The research is largely qualitative due to the nature of the development, aiming at describing characteristic features of inquiry approaches using ICT tools. Research is carried out on all levels in the project, including didacticians’ work conceptualising and planning for workshops and other initiatives. For this reason we use video or audio to record project meetings, activities in workshops, both in plenary and in some groups, and observations in classrooms and school meetings. In addition we write field notes and reflections from observations and school meetings and collect selected tasks and students’ work in computer files.

The workshops are crucial to the developmental work and for building our community. The steps in a cycle of development are not limited to the schools. The
workshop activities can provide input for the start of the developmental cycle or can play a role in the reflection and feedback part of the cycle. Another possibility is to consider the work of didacticians in a cycle of activities, for example about planning and running the workshops, where the step carrying through is the workshop.

Kennewell (2001) suggests concepts of *affordances* and *constraints* can be used to evaluate the implementation of ICT in teaching. The concept affordance was introduced by Gibson to characterise features of the objects, setting an environment which provides potential for actions (Greeno, 1994). Constraints can be seen as limitations, but are not just negative, they are rather complementary to affordances and equally necessary (Kennewell, 2001). Constraints are conditions and relationships that can provide structure and guidance. I regard these concepts helpful in analysing the ICTML work.

Due to limitations of this paper I will the analysis how a few of the tasks and problems posed in two workshops challenged the participants, the outcome of the computer lab session and discussion of solutions in the plenary sessions.

**WORKSHOP ON ICT AND ALGEBRA**

In planning for the ICTML workshop in January 2006 the didacticians considered it valuable to follow up ideas from the previous LCM workshop which focussed on algebra. The close relation between the two projects, where most teachers take part in both, makes it possible to make such links from an LCM workshop to the next ICTML workshop. The LCM workshop dealt with functions, number patterns and how to express connections and the ICTML plan was to inquire into how ICT can support work on similar problems and what affordances and constraints ICT tools provide.

At the start, Otto gave an introduction to how the spreadsheet can be utilised to make number patterns, making connections between cells, formatting the setup to make a suitable lay out and showing how formulae can be hidden and protected.

As the participants started working on computers we observed various examples of tasks on the spreadsheet. Some made a number pattern, a number triangle, similar to the one Otto presented and others used the features of hiding and protecting formulae to make other applications.

An example prepared to investigate number patterns was to reveal what formulae are hidden behind the columns. This heading gives the
task: “Formulae for geometrical figures. Can you find which one?” The spreadsheet shows three columns of numbers and the task for the students is to investigate what geometric measures are calculated in these columns. See the figure above.

When the participants later were presented with this task in plenary session, one response was “it is a rectangle”. Another said “No, it is circumference.” A question arose: Could it be both? This was discussed, and provoked further inquiry: Is it possible that area and circumference of a rectangle, when calculated will give the same number? For what rectangles will this be possible? Could the same be the case for other figures? The discussion provoked new and more general questions that can be followed by further inquiry.

Although using formulae in a spreadsheet has some relation to expressing algebraic connections, in principle, a spreadsheet is an arithmetic tool and not particularly suitable for symbolic manipulations (Dettori, Garuti, Lemut, & Netchitailova, 1995). The formulae uses cell references, not x to express variables. Two teachers wanted to challenge this and asked if it is possible to use x. During their discussion and with some input on naming cells they managed to present the same number triangle with figures and with x. In this case the teachers tried to inquire into the facilities of the spreadsheet, trying to work around the constraints of the software.

MORE THAN ONE TOOL

In the next ICTML workshop a graph plotting software was presented in the introduction. The challenge was to use more than one of the ICT tools available, spreadsheet, dynamic geometry or the graph plotter to investigate the tasks. One of the tasks presented was about making a rectangular shaped sports arena within an area determined by three roads forming a right angled triangle with the small sides 30 and 40 metre. The question is how to place the rectangle and find the maximum, with one side in the rectangle along the longest side or along the two short sides.

Various solutions were presented. A pair of didacticians presented their solution in the graph plotter, indicating that they were quite surprised when they saw the solution. They plotted graphs for possible placements of the rectangle. The graphs of the corresponding areas indicate that the maxima are the same. Could this be true? They showed that they had to use another method for confirming their result. They also prepared a solution in Cabri and found the same result as indicated in the figure to the right.
The reflection and discussion connected to this task raised new inquiry. The task was not specifically asking for area, could we consider circumference? What if the triangular area is not right angled? Could we find the same for any triangle?

WHAT HAVE WE LEARNED FROM THE WORKSHOPS?

The workshops play a key role in developing the inquiry community related to the ICTML project. As teachers and didacticians engaged in investigations together in the computer lab, we came closer to each other and sometimes revealed our lack of knowledge of the ICT tools. This applies equally for didacticians and teachers. The experience is that this makes the roles balanced, and gives a relaxed atmosphere. It is allowed not always to know the answers, and questions that arise will lead to further inquiry. But within the project community we do have some expertise on ICT tools to provide support and suggest what further features to explore in the software. Although the teachers have some basic knowledge of spreadsheets they generally do lack knowledge of dynamic software and graph plotters.

The experiences from the summary discussions looking at various solutions from the computer lab sessions confirm that inquiry took place during the lab session and analysis shows the nature of this inquiry. The reflections carried out in plenary raised further questions to explore and investigate. Reflections provoked questions of what the software can afford and what are the constraints of the software. There were cases of utilising the constraints to support investigations, like in the task of finding what geometric measures were calculated.

On other occasions the constraints of the software challenged creativity and inquiry into the limitations of the software as in the triangle with symbolic expressions. Solving the same task with different ICT tools stimulated participants to look for connections, other alternative solutions to illuminate the tasks and develop tasks in various directions. In many cases questions were raised concerning how to extend or generalise the tasks from the computer lab, like looking at a more general triangle or look for other geometrical shapes that have the same measure of area and circumference. Other questions were about the software and what was possible. In this way inquiry into both affordances and constraints of the software took place.

CONCLUSION

The workshops, as expected, gave a huge stimulation and engagement for the work in the project and for building an inquiry community. Inquiry into ICT tools and their use for mathematics was evident in the discussion with further more general questions proposed and investigated.

REFERENCES


