

STUDENTS' USE OF ICT TOOLS - CHOICES AND REASONS

Anne Berit Fuglestad

Agder University College

In a development and research project over a period of three years, with classes 8 to 10 in school, the aim was to develop students' competence to use computer tools. The aim was that the students should be able to judge what ICT tools are appropriate to use for a specific task. Seven classes with six teachers took part in the project. In a working period in the final part of the project the students work were observed, and afterwards they were given a questionnaire about their experiences in the work, what tools they chose to use and why. The results indicate that about half of the students could make reasonable choices and give appropriate reasons for their choice.

BACKGROUND

The project is based on a social constructivist view of learning, aiming that students will be stimulated to develop their mathematical concepts and understanding of computer tools for solving mathematical problems. This is in accordance with the mathematics plan in the Norwegian curriculum guidelines, L97, which state that the students should “know about the use of IT and learn to judge which aids are most appropriate in a particular situation” (KUF, 1999). The plan expresses a constructivist view of learning and the need to emphasise conversation and reflection. The use of meaningful situations and realistic problems as starting points will motivate the students according to L97. Similar ideas are expressed in other plans and documents, e.g. Principles and Standards for School Mathematics (NCTM, 2000).

A main aim in the project was in line with these ideas to develop the students' competence to use computer tools, and experiment with mathematical connections in an open co-operative environment. The main question for this research was to explore to what extent the students can utilise the ICT tools and make reasonable choices of tools for a specific mathematical task or problem and give reasons for their choices?

In this context I think of ICT tools as open and flexible software, not made for specific topics or limited to teach specific tasks. ICT tools are computer software that makes it possible for the user to plan and decide what to do. Such tools can be used for a wide variety of problems and can provide learning situations to explore and experiment with mathematical connections, and provide new ways of approaching the tasks. I think this is in accordance with seeing ICT tools as cognitive tools that influences the way we develop mathematical concepts and connections, and are reorganizer rather than as amplifiers (Dörfler, 1993; Pea, 1987). Amplifier implies doing the same as before, without changing the basic structure, methods and approaches, whereas “re-organising occurs when learners' interaction with technology as a new semiotic system, qualitatively transforms their thinking” as expressed by Goos et al. (2003).

Based on this view of learning and the potential of computer as mediation tool to provide rich mathematical learning situations we chose software that are open and flexible, provides a learning environment for exploration and investigation, integrate different representations, and stimulate reflection (Hershkowitz et al., 2002). In our project, a spreadsheet (Excel), graph plotter (Grafbox) and dynamic geometry, Cabri, were the main tools together with use of Internet for collecting data and information.

A THREE YEAR DEVELOPMENT OF COMPETENCE

The project lasted three years starting with students in year 8 finishing in year 10 when they ended compulsory school. Seven classes with six teachers from three schools, named S, F and L, took part in the project. All the teachers had some experience of using computers, but the teacher of one class in school S had more experience with ICT in mathematics classes and he was also my co-project leader.

In order to develop the students' competence with ICT tools we planned regular use in the classes and build an open learning environment with options for students choices of tasks, tools and methods. The project leaders provided some material and ideas for use in the classes, both existing material and new. As the project developed some teachers also prepared some material in computer files and shared with the rest of the group. An important issue at the project meeting was to report and discuss experiences from the classes, further ideas and features of the ICT tools.

The teachers were in charge of what tasks and ideas they implemented in their classes. This gives less control from the project, but we think this makes the work realistic and sustainable. The teachers reported in a simple form each term what ICT tools and tasks they worked on in their classes.

STAGES OF COMPETENCE

The development of students ICT competence involve gaining facility with the software and understanding of the connection to mathematical concepts and models that can be expressed with the tools. This competence has to be build over time as students use the tools starting from simple tasks, develop insight and move on to more complicated models using suitable tasks (Fuglestad, 2004):

1. Basic knowledge of the software tools. The students can utilise the functionalities of the software to solve simple tasks prepared for it, when they are told what software to use. For example to make formulas in a spreadsheet when given the main outline or to use a graph plotter to plot a function when the formula is given.
2. Develop simple models. The students can make the layout of text, numbers and formulas to plan a model for a spreadsheet. For a graph plotter they can judge what functions to draw, use different scales on axis, zoom in or out. Be able to use dynamic geometry to make constructions that can resist dragging, i.e. the figure do not fall apart when parts of it, points or line segments, are moved.
3. Judge the use of tools for a given problem. The students are able to think of different ways and means for solving a problem, which software is most appropriate to use or when other methods are better.

I think the stages do not describe levels of competence, although to have some basic knowledge of the software is necessary for stage 2. Stage 2 I think cover several levels of competence. Models on a spreadsheet can vary from very simple to large complicated models which utilises complicated combinations of functions. Stage 3, to be able to judge for example if a spreadsheet is suitable, can perhaps be achieved without mastering very complicated models. In the same way other software can be used on different levels and depth of insight.

Development of mathematical competence is involved at all stages. In order to prepare their own models there is understanding of variables, expressing functional connections with formulae in Excel or Grafbox or analyse geometrical connections and properties and use corresponding menu tools to make drag resistant figures in Cabri. In order to develop this competence the tasks should be developed to give experience with different and typical models (Fuglestad, 2004).

METHODOLOGY

The project was a combination of development and research, with main focus on development of students' competence the first two years, and further development and research during the last year. The work involved project meetings, development and discussion of teaching ideas and teachers implementing ICT use in their classes. I visited the classes to support the teachers, observe and get known to the classes.

Data were collected during all the three years, but more focussed the last year with a close observation period in the last term. Observations and interviews with students were audio and video recorded. The teachers reported their activities in the classes on a simple report form and experiences from work in the classes were discussed in the project meetings. Students work in computer files and partly on paper were collected.

During a few weeks, approximately 8 – 10 hours of work the students worked on a collection of 12 tasks in a small booklet. The tasks were of different levels and degree of openness; some had clear questions and some presented just an open situation with information and the students had to set their own tasks. The tasks were designed to give variation in ICT use, but taken into account that the experiences were different in the classes. A draft version was discussed with the teachers in the previous project meeting. The students chose what tasks they worked on, what order and what tools to use and they could chose ICT tools, mental calculation a calculator, paper and pencil or a combination. They could work alone or in pairs and discuss their solutions or get some help from the teachers.

The activities when students worked on the booklet was observed and partly recorded. The students filled in a log-sheet telling what tasks they solved, what tools they used and who they cooperated with and other comments to the task.

About a week later the students were given a questionnaire to answer individually, via Internet, connected to the work on the tasks, what tools they chose and why, and some questions about attitudes to their work with ICT tools. In the last part of the

questionnaire four new tasks were presented and the students had to read the tasks and comment on what tools can be used, what they would use themselves for and why. The questionnaire had a combination of boxes to tick and open answers where they were asked to write their comments.

CLASSROOM OBSERVATIONS

A task in the booklet was about prices for a bus tour for the class using different bus companies:

“The students at Lie school are going on a tour with their three teachers. They ask for a price offer from three bus companies. Ryenruta gives this offer: 1100 kr fixed charges and 5.50 kr per km, Lie tour service offers: 9 kr per km and Hagenruta offer a fixed price: 4000 kr for tours up to 1 800 km. The students judge three possible tours: to Kristiansand Zoo, about 200 km, Tusenfryd 140 km or Hunderfossen 320 km”

Since no question was included, the students had to judge what to do, how to compare prices and what tools to use.

I observed two boys working alongside each other and discussing how to start. One boy named Tim, was very clear he wanted to use Grafbox since he had used this before; he enjoyed this software and thought he could handle it well. The other one, Hans, wanted to use Excel and was just as sure about it. They worked in parallel, each on their own solution on computers close to each other and could see both screens. They discussed in between if they got the same answers, and how to compare their solutions.

Tim talked a lot, telling what he did:

See when you drive 800 km how much you earn on it. This is crazy. Here there is something variable x , I have to look see, 1100 times five. But can you write five comma five times five point five, or is it a point?

He found something is wrong, and look into the formula he made, then just check with me if the decimal sign is comma or a point in Grafbox (comma is used in Norwegian). He asked me a few questions, when I (ABF) observed, I did not answer directly but asked new questions:

ABF: I do not quite remember, but you can just try a point and see. Software are different.

TIM: Yes, eh it is.

ABF: five comma five times five comma five (expression he wrote in Grafbox)

TIM: Yes five comma five crowns per kilometre.

ABF: Yes.

TIM: And then times x because it is uncertain what number of kilometre.

ABF: Yes.

TIM: Times, will this be correct? I will try. But you, this can not be .. they are not both here.

We looked at the graph window and found the axis adjusted automatically, and made one graph invisible due to the scale. I helped him to change scale and we could see both graphs he had made so far, only the one did not look reasonable.

ABF: Look at this.

TIM: Yes, ok, se now, this “change graph” (referring to the menu in Grafbox) take this. This is strange it is nought to eight.

ABF: What have you written in the box for the formulae, can you have a closer look at it?

TIM: Yes I wrote one thousand one hundred.

ABF: Yes.

TIM: Perhaps that is why (looking at his expression).

ABF: one thousand one hundred, what is that

TIM: This is the ... the fixed price , yes.

ABF: and so?

TIM: I times it.

ABF: Why ?

TIM: Of course it is plus, eh plus.

ABF: Why is it plus, you think?

TIM: Yes, because you take plus the money they charge to drive.

I found in the way he worked he had a good understanding of the software, and how to enter the expression of a function. But he only got confused when the scales changed automatically. He made a mistake using multiplication instead of addition in the formulae for the second graph he made. But he discovered there was a problem and changed the formulae accordingly and then worked on the other price offers.

I moved away for a while and observed at a distance. I could see other students moving over to Tim and Hans, asked what they did and they discussed the solution. From the audio recording I can hear they discussed mainly the task. They seemed to be concentrated on the task even if it was close to the end of the lesson and got fairly noisy in the classroom. Tim also invented his own price models, one very unusual for a bus company, making the tour cheaper for longer journey, and made a graph accordingly. Here he demonstrated that he managed very well the linear functions.

Hans made a model on the spreadsheet, calculating the prices just for the specific distances and prices given and did not make a more general comparison. The two students looked at each others solutions, and discussed what they had done, how to find the connection between the solution and if they gave the same answer. Later when the teacher arrived Hans explained his solution correctly.

What choices did the students make in the questionnaire? The work of Tim and Hans is reflected in the answers they gave in the questionnaire. Tim chose this task about the bus tour as the task he liked to work on, and commented: It was because this I have done this before, in year 8. I felt I got the grip on it.

He chose Grafbox but commented he also solved the task using Excel, and why: Because in this program you can also get an overview on task 10 that is about what pays off different to use things. But on the task I think curve plotting program is the best. And on the question what did you learn from this task: I learned that before you hire a bus you have to check and compare several companies.

Hans chose another task as the one he liked best. The task was to compare prices for a new car and an old car (veteran), where the new got cheaper by 15% and the veteran car more valuable, 10% price raise per year. Starting prices were 190 000 NOK and 15 000 NOK and the task was to find out how long time it will last before they have the same price. His choices were similar to Tim's. He chose both Grafbox and Excel as tools and commented why he liked it: We managed to do the task in Grafbox, vi managed the formulae after a good deal of discussion and some guidance from the teacher. And why he chose these tools: In a spreadsheet we wrote formulae and got the value in number for 5 years. But in Grafbox we made curves, using formulae that we wrote and then we found a point where the cars were of the same value.

The answer from Tim and Hans to the new tasks in the questionnaire had similar references to the tools: Hans wrote for three of the tasks, that all can be solved with a spreadsheet: Because with a spreadsheet you can write in formulae and find exact answer! Tim wrote for one of these: Here you can get an overview of how much to pay depending on how many rounds you drive. And he gave a similar answer to another.

For the last task, finding the largest rectangular sports arena inside a triangular area, Hans wrote; because then you can construct the task and with the help of the menus in Cabri can you solve the task! And Tim wrote: You can find both area and measure of the arena. These answers correspond with the use of Cabri to find the solution.

The two boys' choices of tools and comments to why corresponds with their work in the class. The answers to the new tasks are short, but relevant. These questions came late in the questionnaire and that could explain the short answers.

RESULTS FROM QUESTIONNAIRE – CHOICE OF TOOLS

In the questionnaire the students were asked to choose a task they liked to work on, why they liked it, and tell what tools they used and explain why. The choices were among the ICT tools, paper and pencil or calculator, and several tools could be chosen. The same question was asked for a task they did not like. They were also presented with four new tasks that they had to read and think about, but were not requested to solve. For those questions they were asked what tool could be used, and what tool they would prefer to use and why. In the context of a short survey we can not expect extensive writing, so answers were in most cases short. But some students wrote more, and judged by the teachers in a project meeting, the students gave fairly good answers and they were quite pleased with the amount of writing. There were also several open fields for writing comments.

I looked at the students' choice of tools and the reasons they gave. Many students gave acceptable or good comments. Not all students wrote their comments, the frequency varied from 88 on tasks they did not like to 139 of the 163 students in the project.

About 18% of the students that answered the questions why they chose the specific tools gave good reasons with indication of features in the tools and some very relevant where they also indicated solution methods. Varying on different questions, from 46 % to 60% of the answers given was acceptable and coherent with the tools chosen, but did not give much information. They were for example: this is most appropriate for the task, this is straightforward, it is easy. Other answers were I like this tool or neutral answers, not related to the tools.

The students comments to why they liked a specific task revealed that 39 students answered it was because it was challenging, not too easy and not too much of the same again and again. Examples: This task was quite demanding, but we found ideas how to solve it. It was sometimes a little difficult but very fun when we managed! (Butterpack task) It was fun, but it could have been more difficult (Planning for a sale in a kiosk) But some also liked easy tasks.

SUMMARY AND CONCLUSION

Observations in the classes confirm that the use of computers with the tools in an open setting had a mediating role for students' construction of knowledge. The use of an open learning environment and possibilities for students to make their choices seemed to stimulate this. The students discussed what they see on the screen and asked questions to their peers. Their understanding developed as they worked, and observation of some cases revealed that what they learned on one task, they recognized they could use on a similar task later.

An aim in the project was to develop the students' competence to make reasonable choices of tools. From the analysis of answers to the questionnaire I found that about 18 % gave good reasons for their choices with reference to features of the tools. For about 46 – 60 % of the students' answers was less informative, telling they used the tool because it was "the best choice for this task", "it is easy with a spreadsheet", and similar. For some answers, perhaps a geometrical figure or a table of numbers triggered the answer. These answers can be judged as superficial but the choice of a relevant tool itself has to be counted, and in this setting we can only expect short answers. In most cases their choices are relevant and give a good starting point for the task. I think the depth of choices will increase with more knowledge of the tools.

Another question is whether the students can solve the task with the tools they chose, e.g., if they can make a spreadsheet model when they have chosen this, and tell it is the best choice for this. In order to answer this in full, more analysis of observations is needed. But from the example of Tim and Hans given in this paper, and other cases in the data, indicate that the answers given are closely related to the experiences students had in their work on similar tools and are reasonable.

What level of competence with the tools is necessary to make appropriate choices of tools for a given task? The observations indicate that students can make reflections and choices even if they have limited facility with the tool. Important competence to develop for this is the understanding of how mathematical connections can be represented with the tool. Judging what tools to choose requires, planning without solving, thinking on a meta level, and reorganising the approach to tasks (Dörfler, 1993; Goos et al., 2003). I think this question needs further research.

From answers to what they liked, many students answered they like challenges and many answers indicate they liked tasks that they master, either challenging or easy.

I think implications from this is to give student challenges and variation in tasks, further development of an open learning environment with computer tools as mediators, and options for students to co-operate, discuss and set their own tasks. Further research is needed to gain deeper insight into the connection between students' knowledge of the ICT tools and their competence to choose tools.

References

- Dörfler, W. (1993). Computer use and the Views of the Mind. In C. Keitel & K. Ruthven (Eds.), *Learning from Computers: Mathematics Education and Technology* (pp. 159-186). Springer.
- Fuglestad, A. B. (2004). ICT tools and students' competence development. In M. Johnsen-Høines & A. B. Fuglestad (Eds.), *Proceedings of the 28th Conference for the International Group for the Psychology of Mathematics Education* (pp. 2-439-2-446). Bergen: Bergen University College.
- Goos, M., Galbraith, P., Renshaw, P., & Geiger, V. (2003). Perspectives on technology mediated learning in secondary school mathematics classrooms. *Journal of Mathematical Behavior*, 22, 79-89.
- Hershkowitz, R., et al. (2002). Mathematics curriculum development for computerized environments. A designer-researcher-teacher-learner activity. In L. D. English, M. Bartolini Bussi, G. A. Jones, R. A. Lesh, & D. Tirosh (Eds.), *Handbook of international research in mathematics education. Directions for the 21st Century.* (pp. 657-694). Lawrence Erlbaum Associates.
- KUF (1999). *The Curriculum for the 10-year Compulsory School in Norway*. Oslo: The Royal Ministry of Education, Research and Church Affairs.
- NCTM (2000). *Principles and Standards for School Mathematics*. Reston, Virginia: National Council of Teachers of Mathematics.
- Pea, R. D. (1987). Cognitive technologies for mathematics education. In A. Schoenfeld (Ed.), *Cognitive Science and Mathematics Education* (pp. 89-122). Hillsdale, New Jersey: Lawrence Erlbaum Associates.