

On the use of handheld technology in Math instruction

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Abstract: Computers have been in school since more than a decade, handheld technology, graphing calculators with or without CAS for about five years. But how are these technologies used? Nowadays the curriculum of mathematics for Upper Secondary School in Sweden has a very well pronounced demand on the use of technology in School. Are these demands met? It could be of interest to know how much and in what way technology is used? Does it really enrich instruction and does it enhance understanding of mathematics? One purpose of this work is to investigate the attitudes to ICT of student trainee teachers and their instructors. Another is to find out how technology is used. The answers can possibly indicate if the aims of the Math curriculum are reached. To investigate these questions a survey form was given to 29 student trainee teachers, 20 in mathematics and 9 in physics. Most of the math students were in the second year of their university studies while all physics students were in their fifth and last. A third purpose is to compare the results from this investigation with the results from a big survey made by five student trainee teachers. This survey was taken by somewhat more than 600 students in the Natural Sciences Program in the Upper Secondary School and a related inquiry was answered by 34 teachers. The results from both investigations are similar. Most teachers use the graphing calculator but not so frequent that is demanded by the curriculum. The most frequent student use is to draw graphs and to make calculations. Just a few of the instructors encourage their students to use the calculators to investigate and discover. It is evident that students enjoy mathematics more when they use graphing calculators. It is also interesting to find that several of the student trainee teachers report that they believe that students understand math concepts better when they are using graphing calculators. This is in accordance with the answers given by the students too. It seems as if students are stimulated working with mathematics when they use handheld technology. Students are encouraged to do more mathematics and feel more enthusiastic about mathematics. They even trust that they understand mathematics better. It is evident, that it is very important that the teacher has good knowledge how to use technology, otherwise technology does not give the enrichment that is possible. From survey answers it is also evident that computers are seldom used in mathematics. There are many reasons to believe that the use of ICT in mathematics will be concentrated on handheld technology.

Introduction Computers have been in school since more than a decade, handheld technology, graphing calculators with or without CAS for about five years (CAS is a short for Computer Algebra System). But how are these technologies used? Nowadays the curriculum of mathematics for Upper Secondary School (high school grades 10-12) in Sweden has a very well pronounced demand on the use of technology in School. Are these demands met? It could be of interest to know how much and in what way technology is used? Does it really enrich instruction and does it enhance understanding of mathematics. I am personally convinced that the use of technology can enrich teaching and hopefully make students more motivated and encouraged in their studies. My background for these arguments is that I have been using graphing calculators and the CBL-system when teaching mathematics and physics in Upper Secondary School for the last five years (CBL is a short for Calculator Based Laboratory, a device with the help of which data can be collected into a graphing calculator). In my current position as a teacher at the School of Education at Malmö University I have supervised three students writing exam papers, one in mathematics and two in physics. The purpose of these papers were to make a survey in Upper Secondary School on the use of ICT among selected students and their teachers. Therefore I found it interesting to investigate how ICT is used by other teachers and student trainee teachers to find out if my own impressions on the use of technology are shared by others.

Purpose One purpose of this work is to investigate the attitudes to ICT of student trainee teachers and their instructors. Another is to find out how technology is used. The answers can possibly indicate if the aims of the Math curriculum are reached. Of interest is: How frequent is ICT use in Mathematics and Physics? Are the aims of usage in curricula fulfilled in the instruction of Mathematics? How is the use of graphing calculators influenced by the teachers' skills using technology? How does the skills of the teacher influence the students' attitudes regarding the use of graphing calculators? How well prepared are the student trainee teachers - what knowledge about graphing calculators do they have?

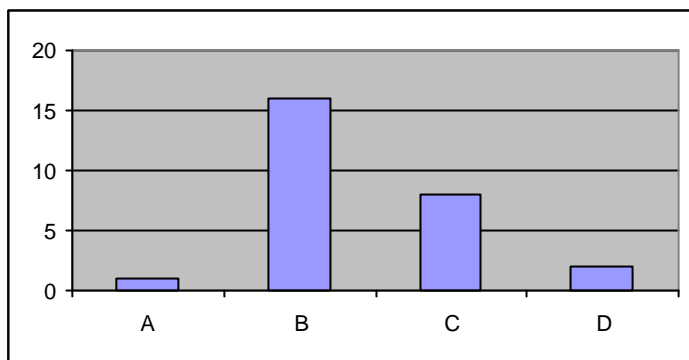
Method To investigate these questions a survey form was given to 29 student trainee teachers, 20 in mathematics and 9 in physics. Most of the math students were in the second year of their university studies while all physics students were in their fifth and last. During this spring semester five student trainee teachers, working with a paper, made a survey to investigate similar questions as those I posed above. This survey was taken by somewhat more than 600 students in the Natural Sciences Program in the Upper Secondary School and a related inquiry was answered by 34 teachers. My results will be compared to the results of their survey.

My own experiences, having taught during somewhat more than six years with handheld technology, will be presented during the discussion.

Results and discussion The leading 12 questions of the survey form was answered by all mathematics' trainees and some of the physics' trainees and the last five was answered by just the Physics' trainees. In this report the focus is put upon the introducing 12 questions, and the remaining questions and their answers are not covered here.

1 Does your instructor use the graphing calculator regularly to discuss topics in Mathematics?

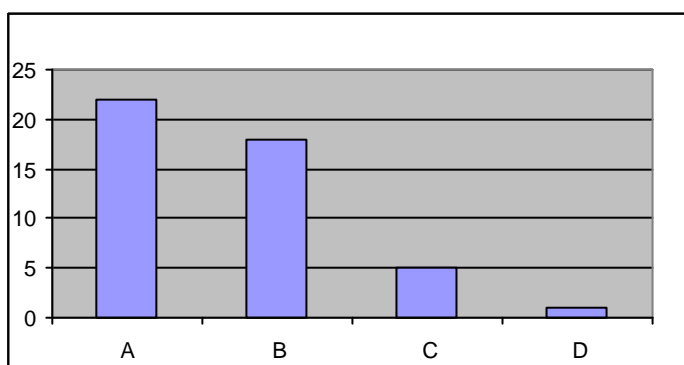
- A Every lesson
- B Every now and then
- C Seldom
- D Not at all



An unexpectedly big group of instructors still do not use the graphing calculator regularly. The alternatives "Seldom" and "Not at all" was used by 10 out of 27 teacher trainees. In some cases the reason is that the instructor teaches vocational programs where graphing calculators are not used at all, in spite of the curriculum requirements (course A). It is remarkable that one instructor teaching the Natural Sciences Program does not use the graphing calculator at all.

2 What actions are performed by the students during instruction?

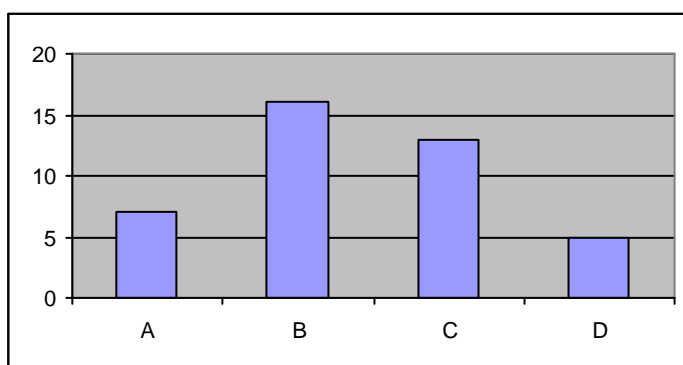
- A. Follows the discussion using their own calculators
- B. Just listening
- C. Making notes
- D. Nothing



Remark: Combinations of answers were given. Students are commonly taking active part, using their graphing calculators, during instruction. As a consequence they do not have time to take notes. Learning by doing is preferred by most of the students.

3 How does the instructor encourage the students to use the graphing calculator?

- A. To investigate and discover
- B. To draw graphs
- C. To make calculations
- D. No deliberate influence

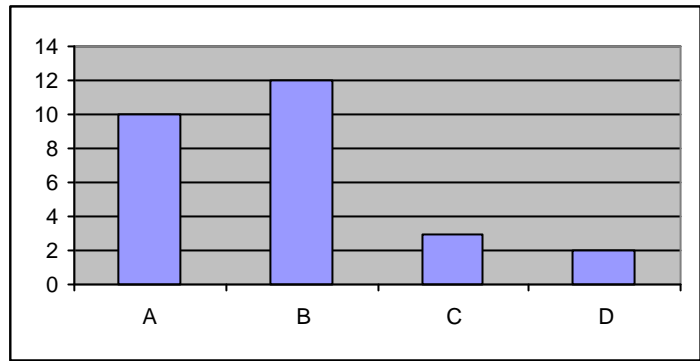


Remark: Combinations of answers are given. The most common answers, of how the students use the calculator, are to draw graphs and to make calculations. Just a few of the instructors encourage their students to investigate and discover. I had hoped that this use would have been more frequent.

4 Does your instructor have a command of the usage of the graphing calculator?

- A Perfectly
- B Well
- C Hardly
- D Not at all

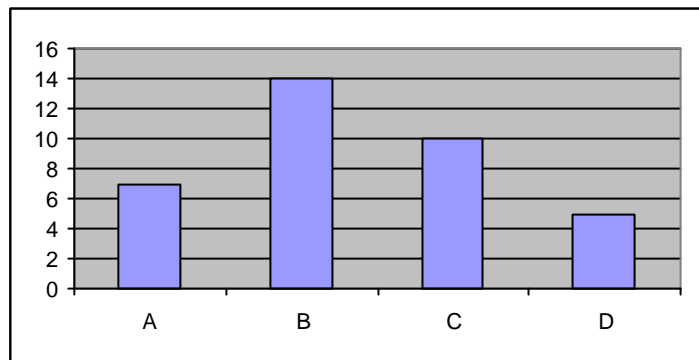
The instructors seem to be comfortable using the calculator, but there are as many as five instructors (approximately 20 %) that do not master the calculator properly.



5 Do you think that the students appreciate to do Math with the help of the graphing calculator?

- A. They believe that they understand better
- B. They enjoy math more than before
- C. No special feelings
- D. Just a fancy toy

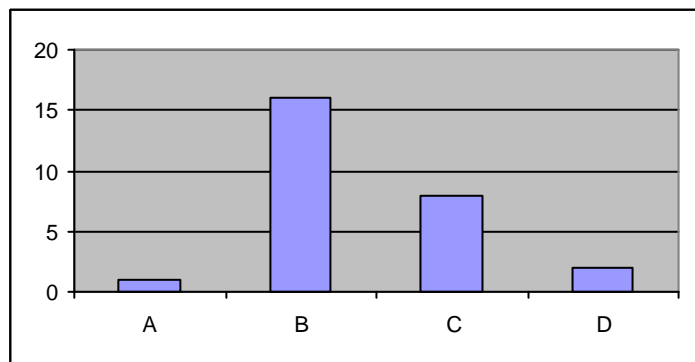
It is evident that students enjoy mathematics more when they use a graphing calculator. It is also interesting to find that as many as 25 % of the student trainee teachers report that they believe that students understand math concepts better when they are using graphing calculators. It seems as if students are stimulated working with mathematics when they use this technology.



6 Is your own knowledge of how to use the graphing calculator sufficient for you to change your way of working when teaching?
My knowledge is:

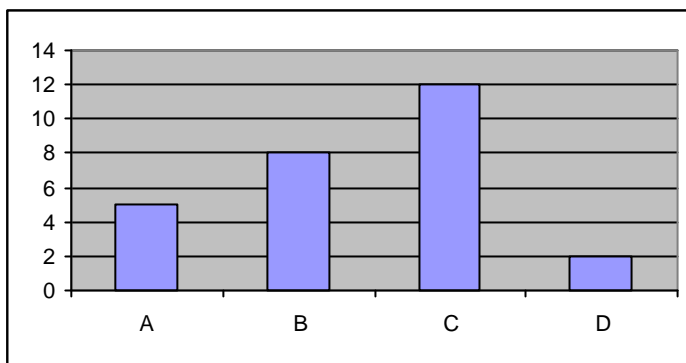
- A Very good
- B Rather good
- C Insignificant
- D Bad

The student trainee teachers report that they have good knowledge on how to use the graphing calculator on average. But it is a bit shocking that as many as ten of them tell that their knowledge is "Insignificant" or "Bad". Attention must be paid to this either in the Teacher Education programme or during the students' Math studies. In the future it is likely that the student trainee teachers have better knowledge, because they will be familiar with the graphing calculator already during their own high school studies. More emphasis on the pedagogical use can then be made during their teacher training.



7 Would you have appreciated if you have had the opportunity to use a graphing calculator during your own studies of Math at University?

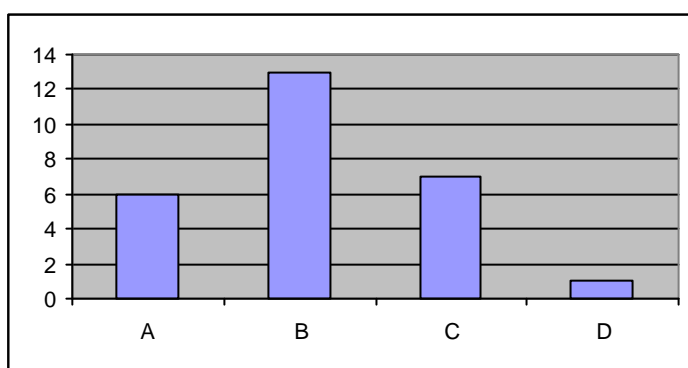
- A Yes definitely
- B Yes probably
- C Probably not
- D Absolutely not



The students are divided into two equally big groups concerning the use of technology during their own math studies. One group is for and one against the use of technology. Today graphing calculators are not used at all during math studies at most universities in Sweden.

8 Is there a need to get more information of how to use graphing calculators to instruct in different manners during your own teacher training?

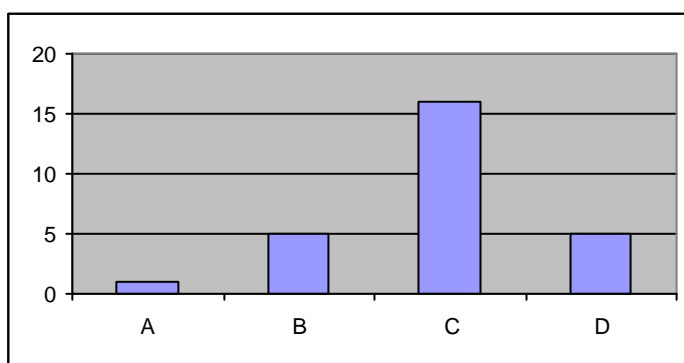
- A Yes definitely
- B Yes probably
- C Probably not
- D Absolutely not



According to the surveyed student trainee teachers there is a distinct need of more information on how to use the graphing calculator efficiently. A comment of interest from the "D-trainee" is: "If I will be forced to use the graphing calculator when I teach my answer would have been alternative A (Yes definitely)."

9 Did you use the graphing calculator when teaching during your training at school (7 weeks)?

- A As often as possible
- B More than five times
- C one to five times
- D Not at all.



The student trainee teachers seem to have made efforts using the graphing calculator during their own teacher training period (7 weeks). To be honest some of them did not have the opportunity to use graphing calculators, since the classes they taught belonged to vocational programs, where graphing calculators are not used at all, despite the curriculum demands.

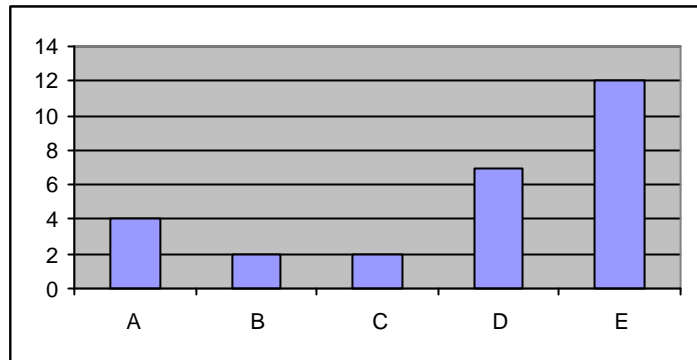
Remark: The reason, why graphing calculators are not used in classes where they could save as an excellent tool to make mathematics more understood, is that the students are not motivated to buy a

calculator. They are of the opinion that the calculator is too expensive for their small use of it. Hopefully schools will arrange for some kind of loan program for these students.

Questions 10 thru 12 cover the use of computers in the instruction of mathematics. Discussion of all of these questions will follow question 12.

10 How often does your instructor use computers when teaching?

- A More than once a week
- B Approximately once a week
- C Approximately once a month
- D Approximately once a semester
- E Never



Remark: Four of the instructors also teach Computer Science!

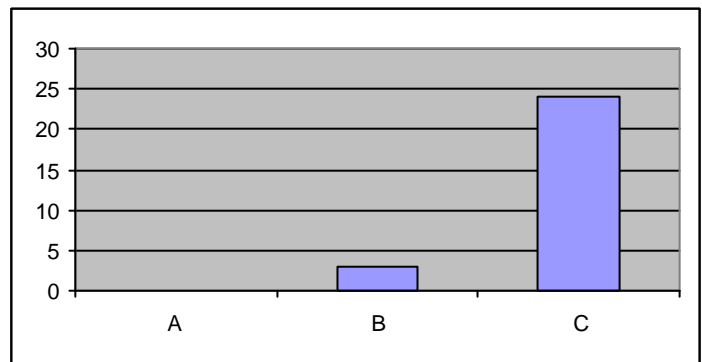
11 What kind of software is used

Excel and Cheops is mentioned.

Remark: Cheops is a Math adventure where students are trained solving a variety of different problems

12 Did you use computers when you were practicing?

- A More than once a week
- B Approximately once a week
- C Never



The use of computers is very low. This is apparent from the answers of these questions. Only four of the instructors, who also teach computer science, are reported using computers more than once a week. The observed frequency does probably not relate to their activity teaching math. A majority of instructors and student trainee teachers have not used computers when teaching. Experiences from my own teaching are similar. I used computers very seldom when teaching mathematics, although I am an experienced user of computers, having taught programming for several years. Why do not mathematic teachers use the computer in instruction? The answer to this question could highlighted by the following: To be able to use computers the class has to move to a different room. Will one of these computer rooms be available at the proper time? If so – for how long will the computers be needed? Probably the teacher wants to illustrate and discuss a few topics with the class and after that there is no further need for computers. Time for transportation is needed. Is it worth these efforts? Many math teachers do not think it is.

The above discussion is based not only on my own experiences but also from discussions with colleagues at several schools. I remember well, that I was very happy the day the graphing calculator arrived. Suddenly it was possible do do a lot of very instructive things with ease interactively with the students. Furthermore it could be done in the classroom exactly when I wanted. My own conclusion, from survey answers and from my own experience, is that there are many reasons to believe that the use of ICT in mathematics will be concentrated on handheld technology. This is not a restriction because the tool is in the hands of every student, free to carry it

with him or her and use it where it is convenient. I am sure that it will not take long before these handheld devices will be more powerful, much cheaper and integrate more common functions found on standard desktop or laptop computers.

Comparing the answers to different questions

How important is the instructor's knowledge of handheld technology?

It could be of interest to find the answer to this question. Therefore I will compare the answer given to question 4 with the answers of questions 1, 2, 3 and 5. A summary of this comparison follows:

The instructor masters the graphing calculator "Perfectly" or "Well"

If the instructor masters the graphing calculator "Perfectly" or "Well" the calculator is more often used by the instructor to discuss math concepts with students (question 1). Those students also use their calculators to draw graphs and to make calculations more frequently than others. It is also possible to observe that learning involves investigating methods to a higher extent (question 3). This result is not astonishing. With a better knowledge the instructors feel more comfortable with technology, understand the possibilities of the tool better and are able to give the students tasks with a higher proportion of research. The answers to question 5 show that those students having an instructor with good command of the graphing calculator also like mathematics better and believe that they understand better. No student having a teacher with perfect command of the calculator regard the graphing calculator as "Just a fancy toy". In the group of teachers with good command of the calculator one student looks at the calculator as "Just a fancy toy". The corresponding teacher never uses the calculator to discuss math concepts.

The instructor controls the graphing calculator "Hardly" or "Not at all"

If the tutor belongs to the group of teachers who master the graphing calculator "Hardly" or "Not at all" the students' attitudes and way of working change correspondingly. The calculator is hardly used or not at all used to discuss math concepts. No students trust that they learn better and almost nobody enjoy working with math more than otherwise. The tendency to look at the calculator as "Just a fancy toy" is higher in this group.

How students work

There is no significant difference between the answers to question 2, "Which actions are made by the students during instruction?", with regard to the answers on question 4, "Does your instructor master the graphing calculator?". The way students work are similar in all groups.

Remarks given

The student trainee teachers had the option to add remarks to most questions. Some of the remarks belonging to the discussed questions are quoted below:

- The graphing calculator is used to enhance the students' understanding (instructor in group "Perfectly")
- Some students do not bring their calculators making it hard to work in the way the instructor wants (instructor in group "Good")
- To work with the graphing calculator is a natural way and gives variety (instructor in group "Good")
- There is no overhead projector in the room (instructor in group "Hardly")
- The graphing calculator is used to draw graphs without any following discussion (instructor in group "Hardly")
- I like the graphing calculator – there is no need for thinking anymore (comment from student in instructor group "Hardly")
- The graphing calculator is used only for calculations, nothing more (instructor in group "Not at all")

Conclusions from this comparison From this comparison it is evident, that it is very important that the teacher has good knowledge how to use technology, otherwise technology does not give the enrichment that is possible.

Comparing my results with those from student papers

During this spring (2001) five student trainee teachers were writing papers during their last semester. One of these is directed towards the use of graphing calculators in mathematics (Andersson, Martin), one paper towards the use in physics (Bengtsson, Peter and Johansson, Lotta) and one towards chemistry (Rask, Örjan and Ulfsson,

Erik). All papers rely upon one big survey among 34 teachers of mathematics, physics and chemistry and also more than 600 students on four different high schools. All students were studying at the Natural Sciences program or the Technical program. Comparing the the results of my survey to those obtained in the survey made by the student trainee teacher writing a paper in mathematics will follow: Extracts from the student paper: The graphing calculator in mathematics instruction – an investigation of use and attitudes (Andersson, Martin).

From the discussion of the student survey: It is apparent that the graphing calculator is used frequently. Three out of four are using it "always" or "almost always" during math lessons. There is no difference between different school years or schools. The picture changes a bit if you just concentrate on the use for drawing graphs. The use is then about 60 % in this group.

More than 90 % of the students mean that their teacher is "positive" or "rather positive" to the use of the graphing calculator. About 60 % of the students like to work with the graphing calculator. The most frequent answer to the question why they like it, is that it simplifies work a lot. About 80 % of the students believe that they master the graphing calculator "good" or "very good". From the discussion of the teacher survey: It is almost a 100 % use of the graphing calculator in all schools. Almost all teachers at all schools use the graphing calculator. Most teachers mean that they have sufficient knowledge to master the graphing calculator. About 30 % of the teachers are convinced that the use of the graphing calculator enhances the learning process and the understanding of the subject. Time savings, increased interest and visualization are highly rated arguments for the use of graphing calculators in instruction.

Excerpts from the conclusions: From my investigation it is apparent that the graphing calculator is commonly used as well as a calculator as a graphing device. That almost three out of four students are using the calculator almost always is not solely positive. Experiences from my own lessons tell me that students give up all mental calculation and use the calculator instead. But two strong arguments for the graphing calculator are, that it makes work during math lessons easier and enhances understanding too. Since I did not have the opportunity to use a graphing calculator during my own high school time I have had a slightly negative attitude to it until now. The comments from teachers why they want to use it and my own experience when I have seen how powerful it is in instruction, has turned me over to the positive side. That it can be used to enhance the understanding of mathematics and make it easier to vary the way to teach are two very strong and convincing arguments.

Summary of discussions

As can be seen the conclusions in this article are similar to those I have got in my small survey. Students are encouraged to do more mathematics and feel more enthusiastic about mathematics. They even trust that they understand mathematics better. There is a minor but significant difference in the reported use and also in how the teachers master the calculator. The student survey reports both a more frequent use and a better knowledge of how to master the graphing calculator. In the student survey the teachers were invited to answer the questions on how frequent they use and how well they master technology. In my survey the student trainee teachers were asked how they looked on their instructors' usage and knowledge. The knowledge of the teacher of how to use the calculator is very important if a good result, i.e., better learning, should be achieved. My own experiences are the same. Having used these devices for a long time when teaching, I have developed relevant experiments and methods, which have received positive reactions from students. In particular, students seem encouraged and appear to understand core concepts better.

Acknowledgements Thanks are due to the Swedish board for ICT support (KK-stiftelsen) who made this investigation possible through financial support. Thanks also to the five student trainee teachers working with exam papers for interesting discussions concerning their works. Their names appear below in the reference list.

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www.skolverket.se (website with curricula – available in English as well)

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Rask, Örjan och Úlfsson, Erik, Grafräknaren och Calculator Based Laboratory, CBL – en undersökning av attityder till och användning av dessa tekniska hjälpmedel, främst i kemiundervisningen på gymnasiet. Examensarbete vid Malmö högskola – Lärarutbildningen juni 2001