

Enriching math teaching by computers

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1. Some studies on computers and student learning

Students are faced with computers both at home and at school; and governments worldwide have introduced schemes to equip schools with classroom computers and internet connections.

Computers and student learning has been studied recently by Thomas Fuchs & Ludger Woessmann (Munich, Germany). Their paper analyzes whether availability and use of computers is related to students' educational achievement. The data used is the extensive student-level data for PISA 2000 (hence the data is observational, not experimental; meaning not random treatment group and control group). They obtained interesting results.

Firstly: Bivariate evidence on the relationship between computers and students' educational achievement is highly misleading:

- computer availability at home is strongly correlated with other family-background characteristics (economic, social and educational family background like education and occupation of parents, immigration and family status).

- computer availability at school is strongly correlated with the availability of other positive school characteristics (resources, institutional features and socio-economic composition).

Fuchs and Woessmann note that in spite of this, bivariate correlations are frequently referred to (even by OECD 2001, p. 118) - showing statistically significant positive correlation between student performance in math and reading and the availability of computers. Yet, Fuchs and Woessmann show that if family background and school characteristics are controlled extensively, the relationship gets negative for home computers and insignificant for school computers. These multivariate results illustrate how careless bivariate interpretations can lead to false conclusions.

Secondly Fuchs and Woessmann point out that the relationship between computers and student learning differs strongly between the mere availability of computers and their use as communication and educational device:

At home: The mere availability of computers seems to distract students from learning, presumably mainly serving as devices for playing computer games. Only by using computers in constructive ways

- the use of computers for emailing, webpage access and the use of educational software can the negative effect of computer provision on student learning be partly compensated for.

At school: The relationship between student achievement in math and the use of computer and internet at school has an inverted U-shape: Students who never use computers or the internet at schools show lower performance than students who sometimes use computers or internet at school. Students who use them several times a week perform lower. Fuchs and Woessmann give two possible explanations:

- Teachers may refrain from use of computers with students of a low ability level, and computer use might actually have decreased student learning. Computerized instruction may substitute alternative, more effective forms of instruction, (similarly in Angrist and Lavy 2002).

- There might be an optimal level of computer and internet use at school, substantially below a use of several times a week.

Having a computer at home and using it at school will almost certainly raise some computer skills. The study of Fuchs and Woessmann suggests that this may come at the expense of other skills (like math and writing). They cite the following hypotheses:

Computers at home tend to be mainly used as toys. Similarly, internet access could offer distraction by chat rooms or online games, reducing the time spent on doing homework or learning. Thus the impact on student learning of the availability of computers and the internet will strongly depend on their specific uses.

Computerized instruction induces reallocation, substituting alternative, possibly more effective forms of instruction. Given a constant overall instruction time, this may decrease student achievement. Also, given that budgets are not perfectly elastic, the introduction of computerized instruction can result in a reallocation of funds in favor of computers, possibly substituting more effective instructional materials.

Computer-aided instruction could also restrict the creativity of children. Computerized programs tend to only allow acting in a predefined way with limited interactive possibilities. This might reduce

students' abilities in terms of problem solving and creativity, thinking in predetermined schemes but not coming up with independent creative solutions by their own.

2. Other research on the economic and educational impact of computers

Borghams and ter Weel (2004) came to the conclusion that the ability to effectively use a computer has no substantial impact on wages; math and writing abilities do yield significant returns on the labor market. (The wage differential in favor of computer users is nearly entirely due to a selection bias of high-skilled workers into computer-using employments).

Angrist and Lavy (2002) report that the introduction of computer-aided instruction in Israeli schools has a statistically significant negative effect on the math achievement of fourth-grade students and a statistically insignificant negative effect on student achievement in other subjects and higher grades.

Evidence so far does not suggest that computers have a substantial impact on the economic and educational outcomes of individuals. Despite numerous claims by politicians and software vendors to the contrary, the evidence so far suggests that computer use in schools does not seem to contribute substantially to students' learning of basic skills such as math or reading. All together, research suggests that the use of computers is a delicate question.

3. The Finnish experience of a Finnish mathematics web magazine.

Finland has made massive investments in equipping schools with computers and Internet connections. To take advantage of these we started in 1996 a mathematics web magazine called Solmu. The address is <http://solmu.math.helsinki.fi>

So far the labor has been university mathematicians, mainly from the Helsinki area. Contact persons have been recently collected from most mathematics departments in the country. Only Internet work and graphic design are paid for. Solmu is supported at the moment by a private foundation.

Net is the main publication forum, but a part of the material is published also as a papercopy and sent to schools who have asked for it, also distributed in education fairs etc. Papercopies are made in a simple, cheap way so that the overall cost is low.

Solmu contains files related to mathematics on a broad perspective. According to a recent study, upper primary teachers and secondary teachers like to read general articles on the importance of mathematics for their own enjoyments and to improve their mathematical education for ex. about history of mathematics.

Very popular are link collections for different levels of school. They need to be well organized and have short descriptions of the contents of the links and how and in which context to use them. Teachers do not have time and energy to work out such collections of links themselves but are happy to use them occasionally if they are well enough structured and worked out for them.

Solmu contains mathematical problems, solutions are given, separately, and also a question and answer service is provided. Many files on ideas of teaching math. have been collected and articles on the results of international mathematics achievement comparisons are also published.

Information on courses for teachers and other activities and contact persons' addresses are also placed in Solmu and updated.

Solmu contains a large file on women, mathematics and information society (Solmu 4/1998-1999). In the address <http://solmu.math.helsinki.fi/1999/2/tilastot.html> are some interesting statistics on women in mathematics and a map of Europe colored to indicate the percentage of women among tenured mathematicians at university level, Originally I prepared the map for the video of European Women in Mathematics www.math.helsinki.fi/EWM. Later on the material on women, mathematics and information society was offered to a publisher who hesitated a little due to the Internet publishing, but then decided to publish a revised version as a book. It seems that for larger files the two means of publishing do not disturb each other - the audiences might be somewhat different and those who like to have a book will buy it, some after being introduced to it in the web. It helps that the price of the book is reasonably low, though.

International collaboration

The role of Solmu has been instrumental in international collaboration with math teachers at all levels. Translations from several languages have been made and collected in Solmu's address in the net. For spreading them Solmu is an ideal way since it is easy for us and free for anybody interested. The content of translations have been for ex. Hungarian mathematical problems - interesting for Finns due to their different mathematical approach. Also files on how to teach mathematics starting from

preschool have been included. Notes from didactical courses given for teachers from primary to secondary level have been taken and submitted to Solmu. In some cases files have been modified just by changing the language and keeping the original illustrations.

Solmu has provided a possibility to accumulate files little by little as resources have been obtained. The biggest problem was to cope with the copyrights, in the beginning nobody seemed to be able to give the adequate wording for an internet copyright agreement.

Solmu collaborates with Hungarian KöMaL <http://www.komal.hu> and British Enrich. <http://nrich.maths.org>

Without Solmu the spreading of translations and all other material would have been impossible, non-commercial net publishing in Solmu was the only - and quite good - solution.

Lately an EU -project called M-buttons, a multilingual mathematics context help for school level, was finished. It offers pupils a possibility to "surf" with mathematics concepts. The original countries involved were: England, Denmark, Poland, Slovakia, Lithuania, Hungary and Finland. <http://thesaurus.maths.org>

English files where Finnish mathematics teachers express their opinion on the recent PISA study are at the address <http://solmu.math.helsinki.fi/2005/erik/PisaEng.html>

Problems: Informing about the existence of Solmu in the media is difficult. The general attitude for mathematics is: nothing interesting for the media, something difficult, dry, engineer-like, which has lost its importance after the computer has become easily available. It seems there is a distribution into two groups- those who dislike and those who like mathematics.

It is also quite demanding to make good Internet files to assist teaching and learning of math. Of course good mathematical understanding and strong, large knowledge of the subject itself is essential. Such people are so rare that they are extremely busy - and tend to be recruited by the industry. It also takes a lot of time to make for example illustrations - and to use this material in classroom needs small groups and a lot of skilled guidance.

Benefits of a webmagazine

- Internet is good for accumulating databases
- It is freely available when and wherever, an easy and cheap distribution channel - once the technology has been purchased anyway
- It is relatively easy to update (this is also a problem, since constant updating is needed and often forgotten)

Wishes for the future

- Solmu would need more stable financial grounds and labor
- We would like to start a database on good applications of mathematics - not trivial and not too complicated. Here international collaboration of mathematicians would be useful, to collect good cases.

References:

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