Continuing education for mathematics teachers of secondary education to use computers more effectively and to improve education

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The present paper has two messages: schools can use technology more effectively, and for the welfare of students, teachers and society, they must do so. Secondly, initial teacher training is not enough, teachers need continuing training as the technology changes, as new and more effective applications are developed and as more is learned about learning with technology. Preparing teachers to use computers is a process that is never completed. If computers are to be effective in schools, however, upending of some present practices must occur, and that frightens many people. Their trepidation is understandable but groundless. Although teachers will have to alter their accustomed practices, they will reach a new level of importance, will accomplish more, and will have greater job satisfaction when schools take advantage of the power of computers.

This study explains why computers have failed to alter education until now, how they should be employed more properly, the startling gains their appropriate use will bring and the role of the continuing training program: computer-aided teaching of mathematics\(^1\) in applying computers in secondary education more effectively. Effective computerised education will happen eventually, simply because the advantages are so monumental: nonetheless, continuing teacher training plays an important role in improving education.

Although I am a Hungarian mathematics teacher and stress the difficulties in Hungarian secondary schools, teachers need to be convinced of favouring improved use of computers, which can remake and improve education throughout the world.

In the first section problems posed by the introduction of computers and networks in schools will be studied. In the second section benefits and challenges of computer-assisted education will be discussed. In the third section I will give a description of a continuing teacher training program: algorithmic mathematics for mathematics teachers in secondary education running currently at the University of Debrecen in Debrecen, Hungary. In the fourth section I will give a brief description of “MATHEMATICA” as one of the software presented during this continuing training and finally research concerning the effectivity of the continuing training mentioned above will be carried out.

I. Problems posed by introduction of computers and networks in schools

In Hungary, there are many problems posed by the introduction of computers, and many of these problems exist in other countries. For example,

1. There is an obvious lack of experience in teaching as well as in staff qualified for teaching using computers and networks, since the schools which are only now joining this movement usually did not possess much or any kind of

\(^1\) Note: when I use the term “computerised education”, I mean more than the basic machine. I include multimedia capability, present and emerging, which computers can integrate and direct, and technology connected with computers like communication through modems.
computer training for teachers and professors. Nonetheless isolated projects did exist, in which such teaching has been offered in school or university level.

2. Language barriers pose a natural problem, slowing down international cooperation on the introduction of networks and computer systems in teaching. Whereas knowledge of English is often possessed by computer-literate, it is sometimes a problem when it comes to the teaching staff and students.

3. Additionally, there is an absence of pedagogical science of computer-assisted learning and teaching, as well as staff qualified for such work, undertaken from a pedagogical viewpoint.

4. The lack of competent teachers in the field of computer-assisted teaching is aggravated by the loss of authority inflicted on the teaching staff by events where the students’ superior knowledge of the teaching matter leads to a “role switch” during class.

5. Also, there is almost no software adequate for computer-assisted learning and teaching whilst the existent programs are few, incompatible or too expensive. The problems arising from the lack of experience and qualified staff are intensified by the non-existence of teaching materials.

6. Many teachers complain about the lack of didactically usable programs for teaching; many declare that they are unable to cope with the simple setting up of the technology they had been offered.

7. There is a lack of communication between teachers; they do not inform each other about the possibilities available to them. A swap of experience and information between teachers does not readily happen.

8. Teachers do not learn in their training hours how to use computers efficiently in classes.

9. Schools do not have qualified technicians or informatics experts with know-how pertaining to the installation of learning and Internet software.

Efforts must be made to ensure that both the teaching personnel and the school supervising bodies understand how vital the competence of the teaching staff to utilize advanced technology is and to expose students to a creative and interactive learning environment is. Furthermore, it is up to them to constantly adapt it to hard and software novelties.

Computer-assisted programs in continuing teacher education need to be designed to supplement the classroom experience and enhance learning opportunities while recognizing the obstacles.

With the help of the article² by Dr Frederick Bennett I have collected the benefits and challenges of computerized education. Bennett believes in a simple solution for solving the crisis in education: free teachers from their usual duties and let computers teach students without an intermediate human instructor. Although his idea is worth thinking over, I consider it to be too idealistic and impossible to realize in today’s schools.

## II. Benefits and challenges of computerized education

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<th>Benefits</th>
<th>Challenges</th>
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<td>• Computers serve as extensions of human minds because they add two startling improvements: blinding speed and massive memory.</td>
<td>• Without human programming, computers are useless.</td>
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<td>• Computers are flexible. As a student learns, the computers will continually evaluate his or her progress. The machine will review, and will permit and encourage the learner to progress faster when the lesson has been mastered, or will slow the pace until the student grasps the material. It will diagnose errors and then provide remedial exercises before moving forward. It will also make lessons stimulating and interesting to enhance learning and retention.</td>
<td>• Machines can break down, and students will be left with nothing to do.</td>
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<td>• Programmers will not have to reinvent effective routines. They will be able to copy and use the skillful teaching techniques that minds of human instructors have developed over many ages. An example of computers imitating teachers is in analysis of errors. Experienced teachers often uncover a deficiency through incorrect answers that a student gives on a test or during a recitation. Whenever a critical error appears, a perceptive teacher understands that the student missed a fundamental point. By capitalizing on this background knowledge supplied by teachers, programmers can enable computers to identify the same difficulties. Human brilliance will be extended through computers.</td>
<td>• Computer programs always have bugs, and again the students will be left without material.</td>
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<td>• Software allows the machine to use ideas of different teachers to reach diverse students. Every computer through its programming can mimic</td>
<td>• Some students will deliberately manhandle computers and destroy them.</td>
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more than one model teacher. It can use whichever style is effective depending on needs of students.

- Computers can enhance other teaching aids. Comparing lessons stored in the machines’ memories with those found in textbooks illustrated another area where programming can improve on current teaching aids. When scientific breakthroughs occur, updated material can be added at once over network connections to all copies wherever they are used.

Some of these objections are valid and some are merely specious. All must be addressed. Answers to these difficulties will be discussed in the subsequent paragraphs.

### Answering objections

- **Without human programming, computers are useless.**
  There are lots of programmers sufficiently skilled to create software that will satisfy the needs of the total curriculum.

- **Machines can break down and students will be left with nothing to do.**
  Malfunctioning machines are not a major problem today and will become even less frequent as computers become ever more perfect. For the rare occasions that a machine fails, the computer of an absent student can be used. Machines will be tied in with the central computer where records and information will be kept. The worst thing that could happen will be that a student must start again where he or she began at the beginning of the day’s lesson. A main computer serving the whole school could fail. The computer hardware is the least important part of the system and could be replaced within hours. Data, which is the vital component will be immediately copied into the new machine from the backup copy.

- **Computer programs always have bugs, and students will be left with nothing to do.**
  Bugs in programs will be continually reduced owing to feedback to programmers. For those that occur, an outside expert will be connected by telephone and the student will go to the lesson of another course while remaining at the same machine.
• **Some students will deliberately manhandle the computers and destroy them.**
Discipline problems will be reduced in computerised education because learning will be more enjoyable than in present schools. If, in rare instances, it did take place, authorities would deal with it just as they do today.

• **Bright students will discover how to use the computers to alter and destroy the system.**
If it is possible, only the brightest of the bright students would ever be sufficiently skilled to penetrate far enough into the system to alter anything. Even then, the system would not be destroyed as safeguards are built into every computer system.

• **Students will waste time if there is no teacher to check on them.**
If students do not interact with the machine for a short, but specified period of time, the computer will be programmed to take appropriate steps to bring the student back to reality. Computers have an ability to stimulate and excite. The interactive features will be a powerful force to keep students working and enjoying their classes.

• **Computers can teach only certain facts, not higher order thinking.**
There are three of the requirements for developing higher order thinking: a good underlying education, thought provoking questions and sufficient time for students to think before responding. Computers can manage these assignments with ease.

• **A machine is unable to make the judgements that a human can make.**
This statement is true: although computers can evaluate technical points like grammar, they can not judge the value of original ideas needed for creative thinking. Seminars, which will form a vital component in computerized education, will solve this problem.

• **Machine can not teach values.**
A machine can be a channel of values because of the information that it provides to students. Since computers will provide a superior education, they will also be able to impart values to students. Moreover, programmers can make adaptations in software which schools can choose, just as these schools choose special textbooks today.

• **A machine can not develop interaction among students.**
As computerized education develops, the computers will be able to develop more interaction, as is presaged today by the interaction that takes place on the Internet. There will be seminars and workshops which will be more frequent and more intensive than in today’s schools. A new element will be added with the contact between students in other schools through telecommunications. These interchanges will be with students who have markedly different backgrounds, since they will live in different geographical locations, including different nations.

• **A machine can not give the necessary and meaningful personal attention to students.**
Every student will have a private tutor in the computer that teaches him or her. Computers will reward students honestly, but prodigiously, as the students advance in their studies. Moreover, the feedback given to students will be immediate which is of more value. Whether this attention is “personal” in a technical sense may be debated, but the effects are equally powerful. The attention given by the machine will be augmented by feedback from human teachers in the individual sessions and seminars.
• **A school system with computers as teachers will turn out automatons not warm, friendly humans.**

Computers alone can not turn students into warm, friendly humans. Development of human characteristics like “warm and friendly” requires interaction with other humans along with direction and role models. Teachers will provide direction and be role models. Moreover, they will do it better than at present because they will have much more time to interact with students because computers will relieve them of the menial tasks such as providing information to students, correcting tests and keeping current on piles of paperwork.

• **Computers can be dangerous to the eyesight of students because of the need to read from the screen.**

Students sometimes strain their eyes from reading books. Colour makes reading less tiring than the old black and white screens. Reading from computer monitors does not seem to be any more dangerous to eyesight than reading from books.

• **Computers can be dangerous because of a malady that affects thousands of people in offices where computers are used regularly.**

This malady, which makes using one’s hands painful, does affect some people who use computers for typing continually for hours every day. In classroom, students will only be at their computers between two and six hours per day and they will not be typing continually at the keyboard. They will be thinking and reading more than they will be typing.

• **Some students will be unable to use computers either through fright or incompetence and will receive no education.**

Programmers can make computers user-friendly and ensure that students will be able to work with the machines. Fears of this type are usually voiced by those without much experience with computers; they do not understand the true ease of present machines.

• **The cost of giving every student a computer is prohibitive.**

The initial outlay of funds can be provided through capital expenditure, and the debt can be paid back through subsequent saving. Reduction in textbook costs will take place and the need for non-teaching personnel will be less. The savings resulting from better student discipline and improved morals of teachers are hard to quantify but should be substantial. There will also be ongoing lessened costs flowing from smaller neighborhood schools that will allow much less costly busing. Savings for industry, the present providers of remedial education, will be substantial. Eventually, the savings to the nation as a whole will be enormous.

• **If computers could be teachers, schools would already be using them in that way since schools now possess millions of machines.**

Use of computers has been poor in education. For computers to accomplish in education what they have done elsewhere, one new element is essential: they must be allowed to teach students. Although we know that most humans do not like change, we always think of ourselves as different. Educators have that same characteristic.
Although millions of computers have been used in schools, they have seldom been allowed to do more than serve as adjunct to teachers.

**Suggested solution**

Teachers are seldom forced to use computers. They usually are permitted to make a choice. Their initial decision to incorporate computers into their instruction has a prerequisite: they must be taught to use computers. This need for training of teachers creates an immediate and major obstacle to full use of computers in today’s schools because most teachers lack the needed expertise.

The success of the introduction of computer-assisted teaching in schools directly depends on the competence of the teaching staff to make use of the new media as well as on their commitment to these techniques. To reach such a competence continuing teacher training, conferences and workshops are necessary for the teaching staff, so that teachers will be able to perform computer-assisted activities in schools and those who do so will be able to share their acquired expertise with collegues who have not reached this proficiency. Also, it is important to train a group of computer and network-assisted teaching experts and to design suitable teaching methods based on the new media. Benefitting from other countries’ positive experience and standards, as well as bypassing certain language barriers can only be achieved by an active participation in international projects based on network computing (via Internet) and by attending international conferences and workshops. The expertise popularization via the mass-media is highly valuable.

In my opinion, the initiative by the printed press to have experts publish reports on computers and networks not only is very necessary because it helps avoid less suitable computer and software acquisitions, but it also is a first step toward a standardization of equipment designated for school purposes. For this kind of standardization it is very important to prepare the teaching staff efficiently within the frame of continuing teacher education. The participants will have access to a common base of knowledge and expertise shared by most of the schools. Thus, a certain kind of hardware and programs will be used by all, so that all students will be ensured an efficient learning based on the same method, soft and hardware. Such standardization is also advantageous regarding the assessment of the costs of future acquisitions, and of computer and applications maintenance, according to the gained expertise. It could be a first step toward a professional computer usage and network administration in schools.

In the following section I will describe a continuing teacher training program running at the University of Debrecen, Hungary. This program is called “algorithmic mathematics”. In my opinion, this continuing teacher training not only is necessary for enabling mathematics teachers of secondary education to apply computers more effectively in education but it also is a first step toward a standardization of equipment designated for school purposes. The participants will have access to a common base of knowledge and expertise shared in most of the schools.

This particular continuing teacher training helps mathematics teachers in considering how they want to prepare students before they use computers, how much to have computers cover, where to place computer instruction into their teaching plan, how to integrate computers with their testing and grading and how much time to give students to interact in computer lessons.
III. Description of a continuing teacher training program: “algorithmic mathematics” for mathematics teachers of secondary education

Participants not only refresh their knowledge gained during their academic studies but they also get mastery in a new, modern field of teaching of mathematics, namely computer-assisted teaching of mathematics. Participants take part in a thorough training in computer science and they learn to use computer programs which enable them to develop new ways of teaching algebra, analysis, geometry, statistics, combinatorics, probability theory and number theory. Those who graduate in the teacher continuing education: “algorithmic mathematics” will become skilled in teaching effectively brighter students as well as students who fall behind. This continuing training enables the participants to learn and apply new scientific results effectively in their practices.

This course is assessed with the award of a certificate of special education with the title of “mathematics teacher of secondary education specialized in computer-assisted teaching of mathematics”. Mathematics teachers of secondary education graduated from any university can take part in the continuing teacher training “algorithmic mathematics”, and the training period consists of four semesters during which the participants are required to collect at least 120 credit points.

Each course consists of intensive, three-day long training (from Friday to Sunday) and in the intervals between these intensive training, guided individual preparations are arranged once or twice a month, four or five times in each semester. Organized consultations are available.

The content of the course has three strands, namely

a) Mathematical Topics
b) Optional Topics
c) Computer-Assisted Teaching (of Mathematics)
### a) Mathematical Topics
- Algebra
- Basics of Analysis
- Geometric Transformations
- Combinatorics in Probability Theory
- New problems of Number Theory
- Concept of Numbers

### b) Optional Topics
- Economic and Political factors of education, current problems of the educational policy
- Basics of Mathematical Logic
- Inequalities
- Elementary Functions
- Algebraic basics of Euclidean Constructibility
- Problem-solving in geometric competitions
- Graph theory
- Additional material in Probability Theory
- Diophantic equations
- Paradoxes in Probability Theory
- Descriptive Topology
- Computing extreme values
- Methodology of Teaching
- Psychology of Learning
- Curriculum Developing

### c) Computer-Assisted Teaching (of Mathematics)

#### Computer Science I.
Introduction to word-processing, change of size and font type, typing, block operations, search, spelling, checkers, formatting, tables, import of data, printing, itemization, mathematical expressions: introduction to spreadsheets, LaTeX: choosing style, documentum elements, change of size and font type, enumeration, tables, constructing mathematical formulas.

#### Computer Science II.
Information networks, Internet, electronic mail, World Wide Web (www), popular www addresses, navigation on the net. Pascal programming, abstract databases, classification of operating systems, DOS, UNIX, DERIVE for computer algebra: creating formulas, factorization, calculation of limit, formal differentiation and integration, solving equations, graphical images of functions.

#### Data Processing and Algorithm
Basic data types: sequence, stack, array, tree. Description and complexity of algorithm. Operations of data types: scanning, search, insertion, deletion, algorithms of searching and sorting and their complexity, processing of character sequences, data compression.
- **Analysis with Computer**
  Illustration of functions graphically, calculating limits of sequences, sum of series, symbolic and numeric differentiation and integration.

- **Curve and Surface Theory**

- **Information Theory**
  Measuring the quantity of information, entropy, conditional entropy, mutual information quantity, games, solving random searching problems by applying information theory. Basics of the theory of coding, construction of uniquely decodable and irreducible codes.

- **Computer Geometry**
  Basics of drawing graphics with computer programs, description of a concrete program language (Pascal). Computer-assisted mathematical concepts (sets, functions, graphics, transformations, constructions). Description of objects in the plane, methods of their graphical representation, graphical programs and image processing applications, applications of software (Derive, MATHEMATICA, CAD, CAD-3D) in geometry.

- **Constructive number theory**
  Chain algorithm, LLL basis reduction algorithm. Their applications: diophantic approximation, Pell-equation, solving Thue-equations, algorithms for polynomials, fast algorithm for finding “small” solutions. Algorithms of algebraic number fields. Prime factorization, presentation of algorithms with the computer programs “Maple” and “Kant”.

- **Statistic with computer applications**
  Descriptive statistics, hypothesis testing, confidence intervals, regression analysis, derivation analysis, multivariate analysis, presenting graphical methods for illustrations. Solving problems of other sciences (physics, chemistry, biology and social science) to emphasize the importance of the role of statistics in the scientific research and creation of models.

During this continuing teacher training, participants are required to collect 120 credit points. Participants are required to collect at least 8 credit points for the completion of pedagogy and psychology, 8 for methodology of teaching, at least 10 for computer practice,
20 for the dissertation, 42 for subjects covering professional material of mathematics, 12 for optional subjects and 20 for subjects covering specialized in computer-assisted teaching of mathematics.

The level of achievement of participants is judged by grades received in subjects which are compulsory according to the curriculum, in optional subjects, in writing and presenting dissertation and in passing the final examination. Dissertation needs scientific research for developing a topic taught during the continuing training as well as researching its applications in secondary school curriculum according to aims of the continuing training.

IV. Brief description of the software “MATHEMATICA”\textsuperscript{3} as an effective application in computer-assisted teaching of mathematics

For proving the usefulness of learning the applications of computer programs I am to present briefly MATHEMATICA which was only one of the software packages used in this particular continuing training for mathematics teachers of secondary education. MATHEMATICA is a powerful tool for computing, programming, data analysis, knowledge representation and visualization of information.

We often need to write programs that carry out complex computations and represent data in a graphical manner to help us visualize a problem we are working on. The computer program MATHEMATICA is able to hold students’ interest, to challenge them, and to make learning interesting. The combination of teachers and programmers using their immense talents while taking advantage of the resources of computers will result in a continual flow of teaching enhancements.

Benefits of using the software MATHEMATICA

- Going beyond teachers’ ordinary skills
  How can computers serve as extensions of human minds?
  Computers share the power of the mind because they are directed by, and are completely dependent upon, the directions that minds of people can give them. They then follow these instructions slavishly. Each instruction for a computer is a simple statement that a machine can read and interpret. One programming instruction can be joined with hundreds or thousands of others. Together they provide awesome power. They can command computers to carry out actions and ideas that are complex, and sometimes that had never previously been contemplated outside the realm of pure human intelligence. The machines can track multitudes of happenings that would be beyond human abilities. For example, computers can count and remember how often a specific mistake is made by an individual student and by thousands of students, and

they notify programmers that a specific error or genre of error is being made frequently by students. Whenever a critical error appears, a perceptive teacher understands that the student missed a fundamental point. With this information, writers of software will be able to redesign the portion of the program dealing with that confusion and they can also enable computers to apply fitting remedies. They will employ a different or expanded method of instruction designed to lessen the likelihood of the mistake continuing to occur. Programmers will again be informed by feedback if the student perplexity is repeated. Problems can be set up in the computer that will show when a specific student deficiency is present. The machines will generate and retain in their vast memories the correct answer and an extensive series of likely incorrect answers. The speed of the machine as it analyzes answers will prove its effectiveness.

Misunderstanding the evaluation of expressions such as

\[ \sqrt{25}^{-1} + \sqrt{4} = ? \]  illustrate the principle

The correct answer, of course, is \( \frac{11}{5} \). A common mistake might give a solution of \( \frac{\sqrt{101}}{5} \) or \(-3\).

Anyone confused by the evaluation of these expressions might come to either erroneous solutions. The computer would also find “\( \frac{\sqrt{101}}{5} \)” and “\(-3\)” in its memory. The program MATHEMATICA has usage messages and should print out error messages when you use it incorrectly or when you give a wrong solution. There are a number of variation of this error message. In any case, inserting a Print expression should quickly show you what is going on. If either answer appeared as the students’ response, the computer would again explain the rules of evaluations of expressions with a square root sign and those of negative exponents and give a brief example or two. It would note that a fundamental error in evaluation had occurred. Then it would provide more problems for the pupil. If a similar inaccuracy reappeared in another response, the computer would be aware of the previous difficulty and immediately provide further and more basic assistance. Additional help would continue until the student showed sufficient understanding of these rules of evaluation. This excellent technique flows from its use of teachers’ understanding of the way children sometimes confuse rules of evaluations.

All numerical and symbolic computations can be easily made by MATHEMATICA. It differs from calculations and simple computer programs in its ability to calculate exact results and to compute to an arbitrary degree of precision.

Software developers will build a series of tests into their programs. Computers will test to make sure that the student understands the material and will use testing to enhance learning. Neither testing nor correction of the exercices will be difficult for the machines.

- Computers are flexible

Students need to be able to progress from a knowledge of facts to arrive at more complex conclusions through intellectual activity. Everyone must have basic information before trying to advance to further conclusions. If students lack sound learning foundations, they can not use facts as the stepping stones to advanced reasoning. Students must have an impetus to take information they have acquired and use it as the basis of developing their reasoning powers. Thought provoking questions
aid this process. Computers can be programmed to ask stimulating questions with varying levels of difficulty that can be effective with different types of students.

Moreover, all computer questions possess an advantage of enormous value – each answer can be immediately corrected, and feedback is given. This capability of a rapid response and follow up to every answer of every student, is a magnificent learning tool, and when combined with well formulated questions, can aid development of critical thinking that is difficult to duplicate except through individual tutors.

Satisfactory responses will bring additional questions aimed at helping students use their reasoning powers. If an incorrect answer is chosen, the computer can provide an explanation of the error. An additional question or questions can be immediately presented. Multiple questions, used this way, can lead students to understand material well, and can teach them to think better.

Both shy and slow students are hesitant to voice their opinions voluntarily in class for fear their peers will ridicule them and their answers. Sometimes those worries are justified. Computers are private. When students are formulating their responses, they don’t need to be afraid of how they will appear before others. For some students, this will be crucial in helping them develop their thinking skills.

Any rational examination of the evils of prejudice shows that it must be eliminated, particularly in schools. Computerized education will reduce prejudice as no other system can. Computers can teach each student at the student’s own level without regard to any of the multiple concerns that could trigger prejudice in a human teacher. Those who are less adept at academic subjects will not stand out. Each student will be working at his or her own computer. Students will cease competing and comparing themselves against each other as frequently as today. They will be concentrating on their own learning. This will appreciably reduce derogatory comparisons with other groups of students.

Computers can also be programmed to provide sufficient time to allow students to think out their answers. “Wait time” can vary and be adapted to the ability of the student. Sufficient time will always be available to aid pupils to profit from thought provoking questions. Computers have both time and patience. Teaching higher order thinking to pupils with the greatest difficulty in mathematical problems requires individual instruction. Every incorrect answer can be quickly analyzed by the computer. Sometimes one incorrect answer may be insufficient to diagnose the type of error. The computer can provide more questions and address possibilities until it finds the key to the mistake. It can then concentrate on providing a remedy for the difficulty. A computer has unique advantages in teaching students to solve these problems because of its ability to be an individual tutor combined with its infinite patience and capacity to keep students interested through rewards.

Computers will be able to break problems into small segments and to formulate questions. They will take students through each level, repeatedly and with many problems if necessary, until pupils begin to understand better. A human teacher could do the same if he or she had only one child in class.

Geometry is a form of mathematics that requires extensive use of higher order thinking. Students often complete a geometry course with only a modest ability to generate proofs. A software like MATHEMATICA monitors students while they are actually engaged in the problem solving process. Students do not have to wait until their papers are corrected to receive feedback. Feedback is immediate, precise,
instructionally relevant, and based on a more thorough analysis of problem solving behavior that would be possible with one teacher and a classroom full of students. The software MATHEMATICA has the advantage of being flexible. When working with functions or sets of data, it is often desirable to be able to visualize them. MATHEMATICA provides a wide range of graphing capabilities. These include two- and three- dimensional plots of functions or data sets, contour and density plots of functions of 2 variables, bar charts, histograms and pie charts of data sets, and many packages designed for specific graphical purposes. In addition, the MATHEMATICA programming language allows you to construct graphical images “from the ground up” using primitive elements. Moreover, MATHEMATICA contains an extraordinary range of functions for doing the computation of science. When these built-in functions are not sufficient for a particular task, there are a wide range of packages that contain hundreds of additional functions. These packages come with every implementation of MATHEMATICA and significantly extend its capabilities, for example: functions of Number Theory.

With computers, the software will determine when a student has learned enough to advance to the next step in his or her education. If the student is showing extra ability, computers will note and encourage the child to build on this capability. For example those students who master sufficient arithmetic to begin algebra could do so whatever their age might be, and regardless of the time it took to reach that mastery.

At times it will be advantageous for a group of students to work on a common project. The computers could schedule students to be in the same room simultaneously, provide the material, and enable students to solve the problem by group action.

Computerized education can always be topical. As information in the world explodes, teachers find it difficult to keep up with all developments. Keeping students abreast of new advances is particularly important in scientific fields. It is much easier to update one computer program that will be used in thousands of classrooms then to update the working knowledge of thousands of teachers now in those classrooms.

On the other hand, computers used by students during the day will be available in the evening for ongoing adult education programs.

Furthermore, it will be possible for certain schools to have certain concepts, which they wish to stress, easily added or inserted into the software for use in their school. Specific schools may want some ideas to receive more attention. Software writers will be able to accommodate their wishes, often with only minimal added cost.

- Computers using the skillful teaching techniques

Analysis of errors will be only one of many instances where the accumulated wisdom of teachers will aid programmers, just as the accumulated wisdom of earlier instructors has always helped new teachers. Software writers will bolster programs with ideas used for centuries. Almost all techniques developed by teachers will be used by computers as educational programming matures. Software writers can use this accumulated expertise to provide instructive material that will make learning lasting and more enjoyable.

When these tested deliveries have been programmed into the computer, they will be used whenever they will help educate a student. Software will enable the computer itself to determine when they are appropriate. Innovation can be duplicated
since software can be the same in all computers. Teachers, working with programmers, can and will develop new programs. The combination of the resources of the two groups will create radically new and exciting breakthroughs in learning. When a new program proves successful in one classroom, it will bring equal benefits in another, just as the same teacher can succeed with his or her teaching method in different classes and schools. A computer program that is able to teach well will never lose its value; it will only be improved.

- **Computers can mimic more than one model teacher**
  A technique that can successfully teach many pupils in different schools may still not be perfect for every student. Needs of students will determine the programs used. When a pupil does not learn, the computer will realise this and will often be able to select another method. Many difficulties that teachers now confront will disappear because of a computer’s ability to provide lessons geared to the precise needs of each student. The material will be delivered when the student is prepared to receive it. The machine will regularly test the student and evaluate results. If the student missed something important, any part of the material can be repeated. Presentations will never be fixed and unchanging. A student will be able to ask questions about almost anything pertinent to the material being taught. The reactions of the student will determine the direction the computer will take to reach the goal of teaching the essential material while graphics entice and involve the student. Interchange between student and computer will allow students to participate intensely while they learn.

- **Programming can improve on current teaching aids**
  Another important educational improvement that the wonders of programming will introduce is flows from the capacity of computers to control and totally integrate audiovisual presentations into the instruction of each student. In computerized education, these can be produced on computer screens of students and software will control them completely.

    You can store everything as plain text that is appropriate for input to MATHEMATICA. With this approach, a version of MATHEMATICA running on one computer system produces files that can be read by a version running on any computer system. In addition, such files can be manipulated by other standard programs, such as text editors. The methods for reading and writing files work in versions of MATHEMATICA on all computer systems. All versions of MATHEMATICA are set up to be able to read notebooks as input. Thus when scientific breakthroughs occur, updated material can be added to all copies wherever they are used.

    The ability to plot and visualize data is extremely important in all of the sciences – social, natural and physical. MATHEMATICA has capabilities to import and export data from other applications, to plot the data in a variety of forms, and to perform numerical analysis on the data.

    Users of every programming language eventually find that the built-in functions are not sufficient for their particular computational needs. They will need to write a program containing the tools offered by the built-in functions with the programming constructs available in the language. MATHEMATICA allows for a wide range of programming styles. MATHEMATICA has the ability to allow the
programmer to write ‘natural code’; that is, code that relies more on the statement of
the problem at hand than on various language styles and idiosyncrasies.

Objections

- **Problems confronting teachers**
  Teachers must be taught to use computers. This need for training of teachers
  creates an immediate and major obstacle to full use of computers in today’s schools
  because thousands of teachers lack the needed expertise. Additionally, future teachers
  now being taught in schools of education are not necessarily equipped to teach with
  computers. Preparing teachers to use computers is a process that is never completed.
  Teachers are already grossly overburdened. Very few teachers have adequate
  time for planning and preparing to use technology. With these problems confronting
  teachers when they use computers, their attitudes are, understandably, often
  antagonistic toward the machines. Present use of computers burdens teachers and
  provides minimal help for education.

- **Problems confronting programmers**
  The present procedures make it impossible for programmers to develop and
  sell distinguished software to schools, and for schools to use software of the highest
  quality. Programmers developing educational software must create software that will
  aid instructors and appeal to those instructors. Although standards for classes have
  been established, each teacher necessarily has considerable leeway in conveying the
  required material to students.
  The absolute quality of the software can not predominate in buying decisions
  by teachers. They must select a program that is compatible with their style of teaching.
  Otherwise, they and the computers will be out of harmony. Even when many teachers
  wish to use computers to teach the same subject, each may prefer different software
  because of his or her unique skills and training. This need to accommodate programs
  to individual traits of instructors creates an immense hurdle for software publishers.
  Millions of different teachers mean multitudes of preferences and goals. This
  overriding obligation to accord with the personal and diverse requirements of teachers
  is basic to the inability of programmers to develop educational software that will take
  full advantage of the power of computers.
  Programming is costly and companies engaged in development need to make
  money. Despite the huge number of students, teacher variations limit potential
  customers for any one program.
  Programmers are not at fault because they can not create one software program
  that will conform to innumerable different teaching methods and styles and that will
  still be exceptionally effective when used in classrooms with students who also have
  different abilities and needs.
  The multiple and major differences among teachers explain a portion of the
  inability of companies to develop remarkable programming. Hesitation of software
  companies to expend the large sums necessary to develop products that will be used
  only by a few teachers adds another hurdle. These, however, are only part of the
  problem. Other serious obstacles also challenge makers of software.
  The ever present and important curriculum requirements are another obstacle.
  Teachers are responsible for covering a specified amount of material in their classes.
Basic student weaknesses affect learning in many ways, but teachers are unable to address all individual needs and still cover the assigned material. Teachers who use computers must finish lessons in the periods allotted. The time they give students to interact with machines comes from that block of available hours. Theoretically, computers should help them contemplate their teaching in less time.

Programmers, therefore, must incorporate their assistance into whatever time teachers can spare to use computers. Poor software means that the almost unlimited power of computers has had a negligible impact in education. Teachers do not regularly use the best software that programmers have created.

Before any teachers can use a finding, he or she must know of its existence and must be convinced of its efficacy. Even if teachers think new ideas will help, they must know how to apply the findings in the classroom and must remember the research when the proper circumstances are present. Overlaying these difficulties is another that accompanies human nature in every activity: inertia. It is easier to do something as it has been done before instead of undertaking a new procedure.

• Problems confronting school boards and superintendents

These authorities can choose programs for the entire system and can buy many copies and impose them on groups of teachers. Software companies embrace this plan of marketing: it allows them to sell larger quantities of the same program. Teachers, however, do not like it. When software is imposed upon them, instructors would have to alter their methods to achieve optimum results. Teachers can not make these changes. They can not revise drastically their methods unless they can also do the impossible: change their individual talents, training, experience and energy levels.

The cost of software is hard to determine, but it is certain that competition will quickly lessen this expenditure as more schools embrace computerized education. To this added costs of file servers, special computer and multimedia equipment and improved wiring are needed.

• Problems confronting students

Most of the computer programs are written in English so it is essential for students to learn this language to be able to operate systems of software. Computers and programs are rapidly becoming ever more “user friendly”. Nonetheless, some programming difficulties are inevitable. Most problems can be resolved through the instructions of the computer. When one arises that the student can not readily solve by working with the available instructions and help from the software, someone who is familiar with the program will be needed.

Conclusion

New educational methods, superior to older ones and easily duplicated, must be developed.

Opponents of serious reform in any area, including education, are seldom satisfied by evidence that a radical new method is efficient. They continually demand more proof. No advocate of retaining today’s system suggests, however, that current educational practices must prove that they are effective. A glance at today’s dilemmas makes it obvious that proof like that will be difficult to find. Only a revolution will bring the turnabout needed to revitalize today’s education. Educators should bring themselves to embrace different
methods. For the nation, however, failure to make changes will intensify and worsen the current situation.

V. Collecting the experiences and opinions of the participating mathematics teachers of secondary education in the continuing education: “algorithmic mathematics”

I designed a questionnaire to find out about the motivation of the participants, the difficulties of studying occurred during this continuing training, the new knowledge obtained and their utilization, the effectivity of this continuing training, possible disappointment in the training, suggestions for making this training more effective, opinions of participants about the future of computer-assisted education. I also requested what kind of changes do the participants consider to be useful concerning the content and course structures to make this continuing education better.

There were 13 mathematics teachers of secondary education who participated in this continuing education and there were 8 of them who were ready to answer to my questions.

1) About the motivation of the participants

I found that teachers are motivated to continue their studies and they are interested in permanent learning and sharing this knowledge with the others. Fortunately the majority 5 out of 8 of the requested participants expected professional renewal and they wanted to refresh their mathematical knowledge. It means that they were really motivated, ready to identify themselves with the aims of the continuing education to develop their teaching capacities.

3 teachers out of 8 considered the continuative education as an obligation. For them it is more difficult to learn the different subjects if they feel to be forced to study without really liking it. Studying under pressure is not an ideal condition for good performance.

2) Difficulties of studies

No teacher answered that the material of this continuing education program presented any problems for them to understand.

3) New knowledge and their utilization

I was astonished to read that 3 teachers declared that they cannot use new knowledge they obtained during this training. On the one hand this may mean that the obtained knowledge was too specialized for teachers to share it with students during ordinary lessons. On the other hand the insufficient technical conditions mean a considerable obstacle of using of computers everyday during lessons. Even if mathematics teachers are ready to study permanently and if they obtain useful knowledge in computer applications they usually can not share their knowledge with the others because of the lack of computers and other technical backgrounds of using computers in schools. Thus continuing education can not be efficient enough in the
long run because participants will soon forget this new knowledge without practicing it.

Computer science provided new knowledge for the majority, 6 out of 8 teachers, which means that in this field teachers need more continuing education.

4) The effectivity of this continuing education

All of the 8 teachers considered this training effective, however, they were disappointed in some things, too.

The participant mathematics teachers were satisfied with the high level of this continuing education. They could obtain new, useful knowledge, a new approach of presenting material and they could refresh their mathematical knowledge. Participant teachers also had the possibility to meet their colleagues teaching in other secondary schools. They also declared that they have learned a lot from each other. Moreover, one of the teachers considered this fact as the most advantageous thing. Another advantage of taking part in this continuing education was that participants could learn the newest research results in mathematics and computer science and receive up-to-date knowledge in these fields. They have learnt different software applications in mathematics teaching. They have also learnt new teaching methods.

5) Suggestions for making continuing education more effective

Answers of the participants:

- “It would be better to do away with repetition in subjects building on each other and to teach new, specialized knowledge instead.”
- “More lessons directly helping the teaching practice in the secondary education should be presented.”
- “Mathematics teachers participating in continuing education need to have a more active role during their own continuing training.”
- “More effective previous assessment of demands is needed.”
- “It should be useful to choose the best professors to give presentations and in some cases the content of the training should be bettered and more practice is needed in computer sciences.”
- “To take advantage of distance learning.”
- “Each subject should contain something new, computer application.”
- “Collecting experiences of participants would be very useful in order to increase effectivity of continuing training.”
- “Teaching methods need improving.”
- “The content of subjects in continuing training should be closer to that of secondary education.”

Commentaries and suggestions

Every teacher considered the continuing training “algorithmic mathematics” to be effective and the majority of them can use this knowledge in their teaching practice.

Teachers need to develop their knowledge and to learn the newest computer applications in order to develop their teaching capacities. The teaching staff of the University of Debrecen is qualified enough to undertake more continuing training for mathematics
teachers and teachers of secondary education that are in need of continuing their studies. They are motivated but not encouraged and supported enough to take part in continuing education. More subjects directly helping the teaching practice in the secondary education should be presented. Mathematics teachers participating in continuing education need to have a more active role during their own continuing training and they need to share their experiences and problems with each other. More effective previous assessment of demands is needed, and collecting experiences of participants would be very useful in order to increase effectivity of continuing training.

Most teachers prophesy a fine future for computerized education and they think that human teachers will remain essential in it although their duties must change. Computers can achieve in education what they have done elsewhere: they can bring a total revolution. The final and more important outcome of computerized education will be that improved and expanded research in education will not lie fallow in scientific journals, but will make the transition from a purely theoretical activity, to classrooms where it can affect learning. In the future, research results will bring better teaching, and students and schools will benefit.

The underlying reasons why new approaches are often in disfavour were enunciated by Machiavelli: “It must be considered that there is nothing more difficult to carry out, nor more doubtful of success … than to initiate a new order of things.” Making the switch to more and effective use of computers can not happen immediately but a slow start is better than no start at all.

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