Impact of Information Technology on Mathematics Education – A Slovenian Experience

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Abstract

This paper deals with the effects of integration of information technology in mathematics education. For this purpose we study the effects information technology has on both the content of mathematical courses as well as the way of presentation of the content.

We find out that the content and educational goals should not be changed radically as the main purpose of mathematics is to enhance the mind of the students. On the other hand, information technology can have both, various positive and also negative effects on the way these goals are achieved. As we know, with the Internet it is easier to include practical examples and project work and therefore the usefulness of the course increases. With the increase in its usefulness, as perceived by the students, other positive effects (such as reduction of needed effort and better clarity) can also be achieved. These findings are confirmed with the data gathered from various surveys.

We focus specially on mathematical education for non-technical students in Slovenia, but the results can be extended to other countries as well.

Keywords: mathematics education, evaluation, information technology, Internet, curriculum changes, cost benefit analyses

Introduction

There is no doubt about two things: that education is one of the most important things in our life and that information technology has strong impact on many aspects of our everyday life. The possibility of using various information technology tools (when teaching and learning mathematics) raises new questions about their proper integration in the school system. This paper tries to answer these questions generally but with special consideration to higher education in non-technical areas.

As information technology is present in every part of our everyday life it is also more and more present in various ways of education. It is especially important for distance learning, but our paper focuses on the possible use in "normal" education. One of the most important points of this paper is that IT is not a panacea for all problems in education, such as lack of funds, unmotivated students and teachers, quick changes in environment, etc. While IT is certainly important and can contribute to obtaining our educational goals, inappropriate use of it can also do more harm than good. In this paper some considerations that should be taken into account when planning and implementing IT use in mathematics education (or education in general), are given.

This paper tries to provide some insight into two separate, although connected, areas. The first topic deals with the possible changes in the syllabus of our mathematical courses at university and other levels of education as well. The question that arises is how information technology (especially the Internet) changes the topics that should be covered in the course in order to maximize the added value for the students. The other topic deals with changes in the way that mathematical content is presented to the students. It asks how information technology can help the students to learn mathematics more easily and efficiently. Obviously, there is no conclusive answer to these questions. Every educational system and every individual educator should find the solution most appropriate for each individual case. Our point is that while information technology can do a lot to improve old ways of education, it will never be able to replace "the human factor."

While this paper is specifically orientated towards the role of math education for college business students, the findings and recommendations can easily be generalized towards other levels of education and other non-technical areas. Most recommendations about the use of information technology in mathematics can also be used for other subjects, although there are certain differences. As mentioned in (Crowe, & Zand, 2000), mathematics is certainly less subjective and less verbal than other subjects.

The structure of this paper is as follows: First, the relevant literature from this field is summarized and critically assessed. Then, the methodology of various surveys that were used for gathering relevant data is presented. The results of surveys are used to support theoretical findings about the role of mathematics education at the university level. Finally, the role of mathematics education is studied within the framework of a previously developed model for evaluation of educational activity.

Review of Literature

The connection between teaching mathematics and information technology has attracted an increased attention of researchers and practitioners in recent years. The following is a summary of some of the studies and findings.

One of such cases is the project described in (Gerber, Shuell, & Harlos, 1998) where two ways of possible use of the Internet are identified:

1. Electronic mail and other forms of communication
2. Information on a wide variety of topics

The students were distributed in two groups ("Internet" and "control" group). The study focused on the second point and found that use of the Internet for math project did nothing to further the students' appreciation for math in other areas. However, due to a small sample, different tasks for students in the Internet and the control group, higher attention to students in the Internet group and subjectivity ("teacher is an Internet enthusiast"), the results of this study cannot carry much weight.

Another example (Moor, & Zaskis, 2000) showed a use of information technology for mathematics education of elementary school teachers on a sample of 36 teachers. According to this study, one of the main advantages of the Web is that it offers students the choice of pathways in acquiring knowledge. In our opinion, this finding should be treated with considerable reserve – after all a student has a variety of choices in "classic" education as well (learning from different books, notes, exercises), although it is undoubtedly true that the Internet increases the number of different possibilities and usually decreases the costs associated with exploring this options.

Another study about the use of spreadsheets for learning mathematics is shown in (Dugdale, 2001) on an example of a calculation of square root with divide-and-average algorithm. While the problem and use is clearly defined and explained in that paper, the difference between such an approach and the classic way of teaching is not shown. Also, positive (or negative) effects of new approach are not clearly identified. Therefore, this paper can serve as a very good example of use of computers in mathematical education, but unfortunately not as a scientific study of effects computers might have on it.

One important finding is that technology improves quicker than the possible ways to use it (Moor, & Zaskis, 2000). One important limitation to full utilisation of information technology in education can be teacher inexperience in using computers and the Internet and limited support for teachers to learn how to use technologies to develop effective, enriching learning experiences for students (Smith, 2000).

Similar limitations are listed in (Moor, & Zaskis, 2000) where a concern for general lack of social interaction when using the Web is also mentioned. Social interaction is not only important to develop social skills of the students, but also because studies show that learning in small groups is often more effective that learning alone in both traditional and computer environments (Hooper, 1992). This is similar to the finding (Luncsford, & Vockell, 1986) that the use of computer in groups is beneficial when the members of the group stimulate one another to think or when they resolve their differences through experimentation.

Reglin (1990) studied the effects of computer-assisted instruction (CAI) in teaching mathematics on a sample of 53 minority prospective teachers. The main finding was that the students who worked cooperatively significantly outperformed those who worked individually.

Owens and Waxman (1994) made a study on a sample of 231 students who were distributed in two groups (one used CAI, the other conventional instructions). The results showed higher scores for students in the CAI group in Geometry but no differences in Algebra. Perhaps even more important – students in the CAI group had a significantly higher attitude towards mathematics at the end of the course.

However, one significant problem about those and similar case studies and project reports should be mentioned. The authors of those studies usually invested a lot of effort, work, enthusiasm and often funds into those projects. Therefore, the success of the project was not necessarily due to the use of information technology tools but could be mainly the consequence of extensive effort. Sometimes new approaches that were used in those projects (a typical example is the use of historical legends to explain Pascal triangle (Moor, & Zazkis, 2000)) could also be easily implemented without the use of information technology.

Obviously, the contribution of these studies to the field should not be denied as they show the potentially new ways to implement information technology into mathematical courses. We should be particularly careful before extending those findings to the general population, where problems, such as unmotivated teachers or students, lack of equipment or management support, should also be considered.

Methodology

In order to empirically confirm our recommendation we used data from 4 studies. The first one is the Third International Mathematics and Science Study (TIMSS) that was carried out by the International Association for the Evaluation of Educational Achievement (Mullis et al., 1998). Twenty-four countries participated in the study in May and June 1995. The data from this study were used to find out the level of mathematical knowledge of Slovenian and other students at the end of high school.

The authors of this article organised the other three surveys. All surveyed students were first year students at the University of Ljubljana, Faculty of Economics. These surveys were intentionally carried out on the whole population of students not just on selected groups with special characteristics or abilities.

The second survey was carried out in the beginning of November 2002. The sample included 297 students. Questionnaires were distributed to the students during one of the lectures in the middle of the term. The questions covered topics such as student’s prior achievement in mathematics, student's attitude towards mathematics in high school and college, their opinions about usefulness of mathematics in various contexts, etc. The results were then statistically aggregated and tested for correlation. Most of the empirical data in this paper refers to the students attending the course Mathematics for Business taught by one of the authors of this paper.

The third survey was done in May 2001 on the sample of 210 students. Students were asked to fill a questionnaire on the Web at the end of computer practicals. Mainly questions about prior knowledge of contemporary information technology tools were asked. Also, the attitude of those students towards IT was tested.

The fourth is an annual teacher's assessment survey carried out at the faculty where students are asked to rate their lecturers and express their opinions about the variety of topics (such as understandability of the lectures and attitudes of the teachers towards students).

Results

First, the results of the TIMSS study were carefully examined. As shown by this study, the mathematics literacy and the use of computers at school or home for Slovenian students do not vary significantly from the average of other surveyed countries. Therefore, the results in these papers can probably be generalized for other countries as well (for detailed results of this study see (Mullis et al., 1998)).

Some of the most significant findings of the second survey (especially the correlation between various factors) are in Table 1 (average results) and Table 2 (correlation between answers).

The third survey (some results are summarised in Table 3) showed that the vast majority of the students regularly use computers, mainly for less demanding tasks such as word processing and of course for surfing the Internet. The population we are dealing with is familiar with computers and their use but has not yet used them for more complex tasks, although it is aware of that possibility.

Discussion

In the continuation of this paper several new ideas and findings about introducing information technology into mathematics education in general and especially at the university are discussed.

The two main questions to answer:

1. How does the information technology affect the mathematics curriculum with special emphasis on curriculum at the university level (the question: WHAT to teach),
2. How can information technology help in achieving the identified goals (the question: HOW to teach it)?

Question	Response
Gender (G) High school average mark (1-5, 5=highest) (A)	72% Female, 28% Male 3,50
Amount of time spent for mathematics in high school (as % of total learning time) (T)	24,5
Usefulness of mathematics in university (U)	3,02
Usefulness of mathematics for learning other subjects (U2)	2,89
Use of Internet for searching mathematically related content (S)	Never(59%), Have used (20%), Couple of times a year (10%), Monthly(8%), Weekly(3%)
Understandability of lectures in the course (1-5, 5=highest) (L)	2,87
How much does mathematics course encourage you to think independently? (1-5, 5=highest) (I)	2,91
Can multimedia web pages replace the lecturer (1-5, 5= totally; 1= not at all)(M)	1,83

Table 1: Results of the survey.

We do not focus on the particular project or individual possibility but try to provide a more generalized view on this topic. The main purpose is to provide a few general guidelines that should be followed in every implementation of information technology in mathematical education.

What to Teach

Before we discuss the possible use of information technology, one other important question has to be answered. Does the information technology dramatically change the topics that should be covered in a mathematical course? At first glance it should. Today it is very simple to perform various mathematics related tasks such as drawing a chart, do a financial calculation or solve a system of linear equations with the use of common tools such as MS Excel (MS Excel certainly offers more features and possibilities than any businessman, lawyer and teacher will use during their professional or personal life). Should the mathematics education then be reduced to teaching the use of information technology to accomplish a certain task?

The answer is a definite no – the main purpose of mathematics should be to help the students to learn how to think, how to apply mathematical concepts to solve everyday problems, and from a more practical point of view, to give them the needed foundation for other more business oriented courses such as financial management or statistics.

The students should be able not only to obtain the results with a series of mouse clicks but should also be able to explain how the results were obtained and most importantly to correctly interpret and use the results. The authors dealt all too often with students who were able to get the correct results on the screen but were unable to interpret them. Alternatively, the student got a wrong answer but took it for granted and did not question its correctness. In order to prevent this, the students should learn how to perform those tasks manually. Simultaneously the students should also learn the use of computer to perform those tasks. Preferably the students would be given opportunity to explore the software themselves with the help of an instructor only when needed.

		G	A	T	U	U2	S	L	I	M
G	Pearson Corr.	1,000	,148	,145	-,027	-,066	-,081	-,004	-,113	-,062
	Sig. (2-tailed)	,	,011	,014	,644	,263	,167	,950	,052	,292
	N	293	293	286	292	292	290	293	293	292
A	Pearson Corr.	,148	1,000	-,212	,057	,009	-,046	,073	,117	,043
	Sig. (2-tailed)	,011	,	,000	,329	,873	,437	,210	,045	,467
	N	293	293	286	292	292	290	293	293	292
T	Pearson Corr.	,145	-,212	1,000	,123	-,019	,151	,011	,105	-,020
	Sig. (2-tailed)	,014	,000	,	,037	,748	,011	,856	,076	,741
	N	286	286	286	285	285	283	286	286	285
U	Pearson Corr.	-,027	,057	,123	1,000	,413	,223	,221	,323	-,047
	Sig. (2-tailed)	,644	,329	,037	,	,000	,000	,000	,000	,424
	N	292	292	285	292	291	290	292	292	291
U2	Pearson Corr.	-,066	,009	-,019	,413	1,000	,139	,007	,255	-,002
	Sig. (2-tailed)	,263	,873	,748	,000	,	,018	,901	,000	,971
	N	292	292	285	291	292	289	292	292	291
S	Pearson Corr.	-,081	-,046	,151	,223	,139	1,000	,161	,079	,068
	Sig. (2-tailed)	,167	,437	,011	,000	,018	,	,006	,179	,246
	N	290	290	283	290	289	290	290	290	289
L	Pearson Corr.	-,004	,073	,011	,221	,007	,161	1,000	,165	-,145
	Sig. (2-tailed)	,950	,210	,856	,000	,901	,006	,	,005	,013
	N	293	293	286	292	292	290	293	293	292
I	Pearson Corr.	-,113	,117	,105	,323	,255	,079	,165	1,000	-,014
	Sig. (2-tailed)	,052	,045	,076	,000	,000	,179	,005	,	,818
	N	293	293	286	292	292	290	293	293	292
M	Pearson Corr.	-,062	,043	-,020	-,047	-,002	,068	-,145	-,014	1,000
	Sig. (2-tailed)	,292	,467	,741	,424	,971	,246	,013	,818	,
	N	292	292	285	291	291	289	292	292	292

Table 2: Correlation between different answers in the survey.

Another important consideration is that information technology tools change quickly and there is no guarantee that the software that is used today by a majority of the students (mainly programs included in Microsoft Office) will still be in use in ten years time. Obviously we can be sure that mathematical laws and equation will remain the same in the future. Therefore the possible transition to new software will be relatively easy for anyone who understands the underlying concepts but could be immensely difficult for those who just learned to perform a certain task with a combination of mouse clicks.

This was a brief summary of our opinion about the importance of mathematics education. In order to compare this opinion with students' experiences and expectations, one of the questions in the survey asked the students to name three main benefits from learning mathematics at high school and at the university. While more than half of the students did not answer this question, the remaining answers can be grouped into three common themes:

1. Performing various tasks (calculation, graph charting) without explaining their purpose. Typical answers include: "I learnt to multiply numbers", "to draw charts", etc.
2. Use of mathematics in every day life ("to calculate odds when betting," "when working as a cashier in my summer job").
3. Mathematics as a "mind enhancer" ("training and awakening of the brains," "systematic thinking," "easier to imagine certain things") - those students emphasized that mathematics helped them to develop logical thinking and therefore made their further education easier.

However, more should be done in making those benefits even more clearly to the students. Some students still do not see any real use of mathematics ("there were no benefits, only worries and problems", "no benefits, because I have never used mathematical knowledge in such a way as in mathematical classes").

While information technology can mostly replace the need to learn mathematics due to the first reason (as those tasks can be performed with the computer), IT is much less important for the second purpose. We can more or less disregard the fact that the personal computer is not available all the time in our everyday activities. The integration between computers and telecommunication devices has already started and we can expect the continuation of this trend due to technology convergence. Therefore, we can expect that the use of hand-held devices (such as Palm) will probably become widespread in the future. It will be possible to solve everyday problems with the use of such devices. However, in everyday life the correct interpretation of the results is at least equally important as just getting the result. By interpretation we mean the ability to understand what the result mean and take actions accordingly. Although in recent years some advances were made in the field of artificial intelligence, we cannot reasonably expect that computer will completely replace a human in this area.

The third role of mathematics education is probably the most important. Special consideration should be paid to the fact that information technology can also do more harm than good if it is used incorrectly (therefore we believe that the decision of many elementary school teachers, who do not allow the use of calculators until the children learn to do those calculations manually, is justified). On the other hand, correct use of information technology can help the students to develop the mathematical habits of mind necessary to function in an increasingly mathematical world (as argued by Cuoco, & Goldenberg, 1996).

As shown, the information technology does not mean major changes in what to teach, but it certainly can help to deal with certain topics more efficiently. This is in accordance with (Crowe, & Zand, 2000) whom claims that IT does not mean removing topics from the syllabus but can liberalise the order in which topics can be presented successfully.

How to Teach

The simplest way to use information technology in every education is to disseminate information. A typical way to do so is to replace older ways of communication with new possibilities offered by information technology and the Internet. The use of web pages to disseminate information and e-mail for two-way communication with students can be very effective as it can reduce time, costs needed to transfer information and also noise in communication. It is also used at the Faculty of Economics, Ljubljana, where students can obtain relevant data (course materials, notices, grades etc.) for most courses on the faculty web pages. This is the system of a so-called “virtual library” (Moor, & Zazkis, 2000). However, this use does not really change the essence of educational process but mainly reduces the costs compared to old system of billboards. Although communication by e-mail can have positive effects (one of them is also that students learn to give details, create complete descriptions and precisely articulate ideas and findings (Frid, 2001)) it probably cannot radically change the whole process.

Therefore, we try to explore the consequences that the more advanced information technology use can have for mathematics education. A possible impact of information technology in the future is described in (Weinstein, 2000) where a case study of how mathematics education could look like in 2010 is presented. Currently the implementation of those ideas is not possible due to technological limitations. Due to quick technological development those limitations will probably be overcome in the next few years. Therefore the implementation of the ideas mentioned in (Weinstein, 2000) will be possible. However, is this a realistic outlook for the future? Will the students and teachers accept it?

One of the interesting findings of the previously mentioned survey was that videotapes or multimedia Internet pages cannot replace "normal" lectures (on the scale of 1 to 5 the average was 1,83). This opinion holds despite the fact that (as shown by the other survey) this population is generally used to the computers, has a computer at home and uses it for a variety of the tasks. The interesting finding is the following: the statistically significant correlation between the attitude to the introduction of multimedia Internet pages and general understanding of mathematics (sig.=0,013) shows that the students with a worse understanding are more inclined to think that the Internet and videotapes are an appropriate replacement for human lecturers. This is a very important finding for every educator who plans to implement part (or all) of class lectures on the Internet. Special attention should be paid to the danger that better students would not use those pages while worse students would use this as an easy way out to somehow complete their course (maybe even with cheating) without actually learning anything.

There is no doubt that computers and information technology have a role in mathematics education. After all, in every country included in TIMSS study the students who use computers regularly also showed a higher level of mathematics and science literacy. However, while the correlation is obvious, the causal connection is less clear. Do the students perform better in mathematics because they are using computers regularly or do more technically and mathematically talented students also use computer more often? The final answer probably lies in the combination of both factors.

Another thing that is usually missing in the studies about the possible use of information technology is a cost-benefit analysis of consequences. While such analyses are widely used in business investments they are often disregarded in education as mostly the benefits of information technology are listed in reports about various case studies. There is no doubt about the importance of investment in information technology and external benefits of it should also be considered. However, this does not mean the costs can be neglected. Whenever a considerable investment is made the costs should be estimated and the projects where costs considerably exceed the benefits should not be run.

The problem is to find the right balance between ferocious advocates of use of information technology and those who see new technology as an expedient for manufacturing graduates more cheaply (Crowe, & Zand, 2000). Cost-benefit analyses of each investment where costs and especially benefits are estimated broadly could be an appropriate answer to this dispute. Obviously we should not forget to include general social interest when estimating benefits.

The possible solution to decrease the costs of the use of information technology is to introduce and use the concept of mass customization. Mass customization is a well known concept in production as it is a paradox-breaking manufacturing reality that combines the unique products of craft manufacturing with the cost-efficient manufacturing methods of mass production (Duray et al., 2000). Therefore we need solutions that would be relatively standardized, but would enable both the educator and the student to easily adapt them to their needs. A standardized program with the possibility to add new modules would be one of the possible solutions (similarly as Excel that has a capability to use third-party add-ins). While the development of such a program is certainly a hard task, the fact that language barriers are considerably lower in mathematics education than in any other field makes this task a little less heavy.

However, even if we assume that the knowledge gained through multimedia tools is equivalent to the classically gained knowledge, important social aspects should also be considered. Detailed study of possible social damages is beyond the scope of this paper, but it should be noted that education is not only about learning how to do something but also to acquire different habits, opinions, attitudes etc. (or as said by (Brown, & Duguid, 2000): “Over the course of an undergraduate degree… they may progress from learning about to learning to be, from, that is, learning about a group of different communities toward learning to be a member of one”). Therefore, the finding of one study (Cameron, & Heckman, 1993) that employers don’t value the candidates who possess all information of their peers but lack the social experience of school as high as other candidates for the same position is not surprising.

The most important conclusion of this section is that while information technology can and should play an important role in education it will almost certainly never be able to replace humans.

Application of Educational Model

The most important considerations for planning mathematical education at various levels were already presented. Sometimes, however, it is easier to think about implementing changes with the help of the model that can be used to identify different goals that should be achieved simultaneously. Therefore, at the end the findings of the surveys and other recommendations are analysed with the help of a recently developed model for planning and evaluation of educational process. This model (Baloh, & Trkman, 2002; Trkman, & Baloh, 2002) identifies four main sub goals that should be achieved in every educational activity. These four components are:

1. Maximize the total final knowledge of the students.

2. Maximize the share of useful final knowledge.

3. Maximize the difference in later learning with or without our educational process (or to say it simple: teach the students to learn much easier in later life).

4. Minimize the effort needed in the educational process.

Those sub goals and the theoretical background of the model is explained in (Baloh, & Trkman, 2002), so we will mainly concentrate on the application of this model to our case.

While the model was previously applied to information technology teaching, it is the first time that the model is applied to the benefits that information technology can bring into mathematics education. Obviously, this division into four sub goals should not be too strict as the goals are often connected and sometimes in contradiction with each other. However, the model can serve us as a very useful tool when thinking about the possible changes that information technology has brought to mathematics education and the usefulness of future changes.

We believe that the third sub goal is probably the most important of the four when teaching mathematics at all levels. The students who wrote that learning mathematics improved their ability to think and solve problems as the response to the question about benefits would probably agree with this statement. Mathematics education undoubtedly enhances the mind of the individual and therefore makes it easier to acquire new knowledge later in life. Emphasising of this goal is similar to the opinion expressed in (Frid, 2001) that courses are designed to provide opportunity, rather than knowledge so that students develop their skills in investigation, interpretation, problem solving, creativity, communication, reflection and met cognition. All those skills are certainly vital to empower students to easier acquire new knowledge during their life either in formal or informal education. Also, mathematics is not just a collection of knowledge and results but also a collection of methods, ways of thinking and habits of mind (Cuoco, & Goldenberg, 1996). Many of the opinions about benefits of mathematics learning in the survey fall in that category.

As business students often question the usefulness of learning mathematics (in the web forum at Faculty of Economics, mathematics is often mentioned by the students as the least useful subject – those opinions mainly refer to university program), the second goal should not be neglected. This goal can be divided in two separate goals that are closely connected. The first one is to really adapt curriculum in such a way that the subjects taught are useful to students in their careers. The second is to also convince the students about the usefulness (or better said: to help them to realize this). As discussed earlier the changes in curriculum due to information technology should not be too drastic. But IT can be extremely helpful to show the students how they can use the gained knowledge. Practical examples can include the project to find different offers for car loans on the Internet and compare them using the knowledge about compound interest account. Another possibility is the use of differential calculus in the analyses of option values (delta) compared to the price of main financial instrument (such analyses are needed in investment banking) – the students can be asked to find the relevant data on the Internet and perform the necessary analyses.

While usefulness is definitely important on its own, our survey also showed that perceived usefulness is positively correlated with both understandability (sig.=0,000) and encouragement to independent thinking (sig.=0,000). This is an unsurprising finding because it is easier to learn something that students perceive as more useful. By increasing usefulness of mathematical education with the use of information technology it is also possible to increase general understanding of the subject and other benefits from it. Even if the topics covered are the same IT can be used to show the students why those topics are useful

The fourth goal should not be neglected, because students generally perceive mathematics as difficult. Information technology should be used to reduce the effort needed to grasp new concepts more easily. Reduced effort does not mean that the final knowledge will be lower, as it is shown in our survey with the negative correlation between the amount of time spent for learning mathematics (as percentage of total time spent for learning) and average mark during high school (sig.=0.000) and at the final exam at the end of high school (sig.=0.000).

The students who have better approach towards learning mathematics (understanding the concepts instead of learning how to solve exercises) can achieve better results with less effort (as this was statistically proven it can also be illustrated with the following quote, "There were some students in my class who had a big book full of exercises. They used to go crazy doing them all. I would concentrate on understanding the ideas and concepts… Then I would solve the problem, looking for different types of problems – instead of doing the same type with different numbers… I did much better in the course..." (Weinstein, 2000). This can most easily be done with increased understandability of the lectures (also with the help of information technology) although as shown by teacher assessment survey this level is already reasonably high (average 4,36 on a scale of 1 to 5).

Conclusion

In the paper some important considerations about the proper use of information technology were presented. The effects of regular use of IT on understandability of the lectures, perceived usefulness by the students and students' attitude towards mathematics were studied. Interesting results of the survey showed positive correlation between perceived usefulness and understandability. Therefore some possible uses of the Internet to increase the students' opinion about possible benefits from mathematics are shown.

The main point of this paper is that integrating information technology into mathematical education (or any other education) is not simply a problem of getting proper equipment (computers, software, connection to the Internet etc.) and proper education of all teachers but goes far beyond that. Every inclusion of information technology into education should be carefully examined along with its benefits and costs. As shown in the last chapter the newly developed model for evaluation of educational process can serve as a useful guide when estimating possible benefits.

Even the students who are familiar with the use of computer do not believe that information technology tools can replace human lecturers. Therefore IT should be used to complement human instructors and certainly not to replace them.

While the surveyed population were first year business students at the Faculty of Economics, University of Ljubljana, the results can be extended to other countries as well since (as shown by the TIMSS study) there are no major difference between Slovenian and other students in the level of mathematical knowledge when entering university.

The main purpose was not to provide conclusive answers but to raise different questions that should be considered when implementing information technology either at one institution or at national level. The positive and negative effects of integration of information technology in mathematics education depend on proper answers to those questions in each individual case.

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