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ABSTRACT

This paper examines why the number of high school mathematics teachers who integrate computers into their math classes remains relatively low by analyzing the attitudes of prospective high school mathematics teachers. Data were gathered from written questionnaires and class discussions of four classes of prospective high school mathematics teachers in a course on integrating computers in the teaching of mathematics. Analysis of pro and con arguments about integrating computer activities in their future teaching of mathematics revealed a two-dimensional theoretical framework of cognitive, affective, and social factors according to the five categories that represent the class's components; i.e., the learners, the teacher, the learning material, the class atmosphere, and the learning environment. The paper briefly explains what each category means and presents pro and con arguments in each category as presented by the prospective teachers. (MES)

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Attitudes of prospective high school mathematics teachers towards integrating information technologies in their future teaching

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Introduction

Hundreds of papers are published nowadays arguing that computers have become an integral part of our lives and, as such, should be integrated into educational systems as well (Cf. Eden, Eisenberg, Fischer and Repenning, 1996; Edelson, Pea and Gomez, 1996; Flake, 1996). Since such integration requires a change in teaching methods, teachers play a central role in such a transition. Of course, this is also true in regard to teaching of mathematics.

There are many benefits in using computers in our math classes (Cf. Sfard and Leron, 1996). However, as it turns out, the number of high school mathematics teachers who integrate computers into their math classes remains relatively low.

This paper tries to explain why this is so, by analyzing the attitudes of prospective high school mathematics teachers towards integration of computers in their future math classes.

Background

Data presented in this paper have been collected during these past three years (1996-1998). During that time, I have been teaching courses about integrating computers in the teaching of mathematics for prospective high school mathematics teachers. In the course, the prospective teachers work with, and experience, both general computational environments (such as the Web), and mathematical software tools (such as dynamic geometry environments). Since no one can guaranty that the specific computational environments that the prospective teachers meet in the course will be used in the future, emphasis is placed on general principles and ideas of integrating computers in math learning and teaching.

The course takes place in a computer lab. Most of the time, the prospective teachers work on activities in pairs in one of the computational environments, guided by worksheets I prepared in advance. Each class session ends with a class discussion and reflection of what was learnt during the lesson. On the one hand these discussions address mathematical topics, and on the other hand, they address pedagogical issues (mainly, cognitive and social ones). Assignments in the course include planning of activities for high-school pupils in the various computational environments, reading papers and submitting theoretical discussions.

Data presented in this paper was gathered from four classes of prospective high school mathematics teachers (total of ninety-four prospective teachers). The issue of pros and cons the integration of computers into mathematics classes was the subject of written questionnaires and of class discussions.

Results

The analysis of the prospective teachers' pro and con arguments about integrating computer activities in their future teaching of mathematics, revealed the following two-dimensional theoretical framework:

	learner	teacher	mathematical content	learning environment	class atmosphere
cognitive factors					
affective factors					
social factors					

In what follows I present the arguments according to the five categories which represents the class's components, that is: the learners, the teacher, the learning material, the class atmosphere and the learning environment. I briefly explain what each category means and present pro and con arguments in each category, in relation to most of the psychological aspects, as presented by the prospective teachers. For reasons of space limitation, I only present a sample of the arguments here. Additional arguments will be presented in the talk.

Arguments focused on the learner: In this category there are arguments the subject of which are: pupils' ways of thinking, pupils' system of learning-values, and students' attitudes and behaviors.

SAMPLE OF PRO ARGUMENTS	*SAMPLE OF CON ARGUMENTS*
Cognitive aspect: Learners can conjecture, check their conjectures, improve their solution without being embarrassed when making a mistake, work in teams conducting a "mathematical conversation", and explore mathematical ideas guided by the extent of their curiosity. All this is done when learners know that the teacher is in the class if additional help is required.	***Cognitive aspect:*** Some of the may progress without understanding previous stages. ***Affective aspect:*** Some students may feel they have too much freedom.

Arguments focused on the teacher: Interestingly, in this category most of the prospective teachers' arguments were *con* arguments. A plausible explanation for this fact is that the prospective teachers do not feel secure in this mode of teaching. Indeed, in the table below we can see that most of their worries deal with the teacher's role in a class that learns with computers. In my opinion, the imbalance between the pro and con arguments presented in this category is significant, and may partially explain avoidance of the part of some teachers of integrating computers in schools in general and in mathematics classes in particular.

SAMPLE OF PRO ARGUMENTS	*SAMPLE OF CON ARGUMENTS*
Cognitive aspect: The teacher becomes a guide and is not the focus of the lesson anymore. Moreover, being released from his or her traditional centered role, the teacher can follow the work of the students by looking at the computer screens.	***Cognitive aspect:*** The computer becomes the class's "brain". The teacher's role is simply to navigate, guide, and connect students' knowledge with official mathematical knowledge. ***Affective aspect:*** The computer is conceived as being more clever than the teacher because of its numerous abilities and the fact that it does not make mistakes. ***Social aspect:*** Lessons in computer labs are not carried out in the traditional manner and traditional obedience is replaced with some noise. As a result, teacher control and authority are lost.

Arguments focused on mathematical content: In this category there are arguments whose focus is on mathematics. The fact that the prospective teachers present *mathematics* as the subject of their arguments is important since such arguments deal with abstract ideas and topics.

SAMPLE OF PRO ARGUMENTS	*SAMPLE OF CON ARGUMENTS*
Cognitive aspect: The way mathematical ideas are represented	***Cognitive aspect:***

on the computer stimulates the pupils' thinking, leads them to connect among mathematical topics and enables them to think broadly without being distracted by technical problems. Moreover, the fact that computers may serve as cognitive partners influences the kind of activities suggested to pupils, such as multi-solution problems. Such problems encourage pupils' creativity, motivation and inventiveness and improve their mathematical thinking.	Since learning with computers emphasizes learning processes over final results, it is much more difficult to assess pupils' knowledge.

Arguments focused on the learning environment: Arguments in this category deal with the nature of learning with computers and with the barriers and opportunities one encounters when learning with computers.

SAMPLE OF PRO ARGUMENTS	*SAMPLE OF CON ARGUMENTS*
Cognitive aspect: Computers provide a world of mathematical experiences, personal experience for all students and an ability to see, feel, move, construct and manipulate "things".	***Social aspect:*** These kinds of problems are mainly connected with the school system: Sometimes computer labs are not available; in other cases – there are not enough computers and it is necessary for five pupils to share one computer.

Arguments focused on the class atmosphere: The prospective teachers' arguments in this category refer to those things going on during a lesson based on computer activities.

SAMPLE OF PRO ARGUMENTS	*SAMPLE OF CON ARGUMENTS*
Social aspect: Computers provide: - A possibility to communicate with pupils around the world. - An opportunity for classmates to work in teams and to collaborate.	***Social aspect:*** Since computers are expensive, not all pupils may be able to afford them. Thus, those pupils who have computers at home may progress faster than pupils who do not, and therefore will have an advantage over those who do not own PCs.

Discussion

The above analysis describes prospective teachers' attitudes towards the integration of computers in their future teaching of mathematics. From the prospective teachers' answers we can learn that they refer to the main participants of the lesson: Learners, teachers and the learning material, and to the interaction among them: the learning environment and the class atmosphere. Moreover, we can see that the presented arguments deal both with cognitive, social and affective aspects. It is interesting to

note that in many of the written responses, after specifying the pro arguments and the con arguments, many of the prospective teachers have added a remark in the following spirit: *It is worth integrating learning with computers together with learning and teaching without computers*. Such a statement indicates that the prospective teachers do not take it for granted that computers would solve all problems embodied in the complexity of learning and teaching processes, but rather that, the integration should be given serious thought in each individual case. In regard to this, one of the prospective teachers wrote: *The computer can supply information, but we may lose its potential if we do not educate our pupils to use that information. Many databases are accessible now but our target should be the analysis of this data and not just getting it.*

Another interesting observation is that both in the teacher and in the learning environment categories, the number of pro arguments is significantly lower than the number of con arguments. Moreover, the situation is reversed in the learner and the mathematical content categories (that is, the number of pro arguments is significantly higher than the number of con arguments). This can be explained by the prospective teachers' lack of teaching experience. Thus, it is reasonable to assume that in addition to their anxieties as new teachers, they express concerns which stem from the integration of computers. These concerns are especially expressed in the teachers and the learning environment categories. The question to be asked now is: Why do they see the benefits when they think about the learners and the mathematical content? Based on the class discussions, in which the prospective teachers' arguments were elaborated, we can learn that prospective teachers are faced with a conflict. On the one hand, they believe that teaching and learning with computers may improve the learning of mathematics. This belief is reflected in the number of pro arguments in the learner and the learning material categories. On the other hand, they feel that such integration may change the traditional teachers' role, a role which they are familiar with from their experience as school pupils. These concerns are reflected in the number of con arguments in the teacher and the learning environment categories.

It is known that motivated employees introduce positive changes into their organization, while unmotivated employees are satisfied with existing situations in their organization (Inamori, 1985 in Senge, 1997, p. 147). Looking at schools as organizations, we should ask ourselves questions such as: How to motivate the

prospective teachers towards integrating computers into their classes (in those cases in which it is appropriate to do so), regardless of anticipated difficulties? How to help them cope with their worries from the expected change in their role in the class and in the class atmosphere?

One of the outcomes of the research is a set of activities currently under development. The aim of the activities is, on the one hand, to help the prospective teachers cope with their concerns, and, on the other hand, to encourage them to be guided by their beliefs when they feel that the integration of computers in mathematics classes may improve the learning of mathematics on the part of their pupils. One activity is based on simulation games, i.e., playing situations that may occur in classes learning mathematics in computer labs. The idea is to let the prospective teachers play unfamiliar situations, and thus let them get a sense of such situations in a supportive environment.

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