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Teachers and Research Studies in Computer–Assisted Learning

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"In computer-assisted learning (CAL), small group problem-solving instruction is efficient. CAL should shift the focus of school mathematics toward goals for problem solving and mathematical modeling. For the shift, the roles and responsibilities for teachers are very important in CAL" (Heid et al. 1990).

I. INTRODUCTION

Since the invention of the computer, its' development has progressed remarkably. At the same time, the influence of the computer has affected all parts of our life. In mathematics education, there has been a lot of controversy about whether or not computer technology can be used effectively in teaching school mathematics. By 1980, sufficient experience had been accumulated with computers in education so that underlying questions regarding their nature and appropriate use become clearly articulated (Kaput 1992)

There have been a quite number of research studies into the effectiveness of computer-assisted learning (CAL) in recent years, most of which gave positive results (Hartley 1977; Thomas 1979; Burns & Bozeman 1981; Bangert-Downs 1985; Mancey 1987; Fey 1989; Olive 1991). Even though teachers should use computers to enhance their knowledge and to reinforce their teaching skills, the practical challenges remain in real classroom teaching. Using computer in teaching and learning school mathematics has lots of implementation problems.

The question is how can one plan and conduct teaching, and evaluate students' performance in the CAL environment. Several interesting issues on teachers' beliefs, their implementation of CAL, and their roles and responsibilities in CAL environments will be discussed. In addition, we will give a set of directions for the teacher training program of implementing CAL. Before mentioning the issues, we need a clear definition of teaching and research on teachers in CAL.

II. DEFINITION OF TEACHING AND RESEARCH ON TEACHERS IN CAL

A useful broad definition of research is disciplined inquiry (Cronbach & Suppes 1969). The term inquiry suggests that the work is aimed at answering a specific question. The term disciplined suggests not only that the investigation may be guided by concepts and methods from disciplines such as psychology, history, philosophy, or anthropology but also that it is put on display so that the line of inquiry can be examined and verified. Research in mathematics education, then, is disciplined inquiry into the teaching and learning of mathematics (Kilpatrick 1992).

Teaching is used to refer to ways of making something known to others, usually in the routine of a school. Henderson (1971) gives a more formalized conceptualization of teaching by interpreting teaching as a ternary relation T(x, y, z); the domain of x constitutes "sequences of 'actions' of an object that is defined as a teacher", the domain of y is the set of teachable objects, and the domain of z is "sequences of actions or behaviors of a person who is identified as a learner".

Using computers in teaching mathematics is considered as part of teachers' activity that helps students' learning and mathematical understanding. Research, therefore, on teachers in CAL for mathematics is disciplined inquiry into the teaching focused on the domain of x in Hendersons's ternary relation T(x, y, z).

Research on teachers' beliefs, their implementation of CAL and their roles and responsibilities in CAL is helpful to analyze implementation problems in CAL, and to develop CAL for mathematics education. Thus, it is worthwhile to identify teachers' beliefs on CAL.

III. TEACHERS; BELIEFS AND THEIR IMPLEMENTATION OF CAL

The impact of computers on school life does not match the early claims of the "computer enthusiasts". As Becker (1991. p.6) put it,

> There were "dreams" about computer-using students··· dreams of voice-communicating, intelligent human tutors, dreams of realistic scientific simulations, dreams of young adolescent problem solvers adept at general-purpose programming languages —but alongside these dreams was the truth that computers played a minimal role in real schools···. As we enter the 1990's, it is important to understand how much of that early limited reality still

> remains and to understand how much of the idea of transforming teaching and learning through computers remains plausible. We need to be aware of the "old habits" and "conventional beliefs" that are common among practicing educators and the "institutional constraints" that impede even the best of intentions to improve schooling through technology.

Again we have the juxtaposition of beliefs and classroom cultures. Thus the "average" picture painted is one of stability of attitude to computers with possible incremental rather than major change. Absent from such a review is the, admittedly rare, imaginative usages that have been researched by Sheingold and Hadley (1990).

They reported that amongst "accomplished teachers" —those reputed to be especially adept at incorporating the computer into their classroom practice –the majority had been teaching for over 13 years, worked in schools generously endowed with hardware and had easy access to technical and educational assistance. Given these conditions, teachers reported that using computers had radically changed their conceptions and methods in ways that could be interpreted as "constructivist" —becoming more student-centered in terms of expectations and direction of learning. Prerequisites to reaching such a position were identified as resources, time and perseverance-factors necessary to survive the phase of "disruption" in the face of an innovation and maintain a willingness to reflect upon the new classroom dynamic.

Sutherland, Hoyles and Noss (1991) came to rather similar conclusions after the Microworlds projects where they had set up a course of in-service education for "expert" secondary mathematics teachers. In addition to the time and support required to integrate computers into practice, the researchers also stressed the need for the teachers to experience the power of the medium for expressing their own mathematical ideas. It is important to underline here that they recognized from the outset that any study involving innovation with mathematics teachers, must of necessity look at teachers' belief as well as their practices —they aimed to map the interrelationships between beliefs and practices.

The researchers were interested in how the interactions of the teachers with the computer activities for teaching mathematics, and the ways teachers incorporated them into teachers' practice, provided a window onto their views and beliefs about mathematics teaching —but in a dynamic way, whereby beliefs and course activities were both included in the process of change.

Becker (1987) showed us a picture of teachers' behaviors and beliefs in CAL. Among the teachers who used computers for mathematics instruction in elementary schools, high-experienced (more than 3 years using computers for teaching) and average-experienced (1–3 years teaching using computers) teachers used computers much more frequently than novice (less than 1 year using computers for teaching) teachers.

They taught students of somewhat higher ability, but in many ways their pattern of use was similar to the way more typical "novice" elementary mathematics teachers used computers. They used drill-and-practice programs at least as frequently, but they also mixed in tutorials, programming, and word-processing more often than those computer-using elementary mathematics teachers who were less "experienced". As with the less expert teachers, only a minority of the more expert teachers were able to give all students in the class computer time on any one day. They gave students somewhat longer turns. But seat work dominated the time of students waiting for their chance to use computers as much as in other classes.

Compared to elementary mathematics classes, mathematics classes in grades six to eight that used computers used them much more often in computer laboratories and used them more for remedy and less for enrichment. About as many middle grade mathematics teachers (45%) saw computers as a way of keeping students occupied after they completed their other work as reported using computers for remedy (44%).

Middle and high grade mathematics teachers used computers somewhat differently according to their own computer experience. High-experienced and average-experienced teachers overwhelmingly used computers in labs, but novice teachers used them primarily in classrooms.

Therefore, experienced teachers had a higher computer ratio (computers to students). And the average-experienced teachers used computers more often for remedy and for providing activities to students who finished their other work than did other middle grade mathematics teachers. They are also the ones who most often had students do their computer work cooperatively.

The high-experienced mathematics teachers at this level are distinguishable instead by their greater use of computers as a regular part of class instruction (rather than for enrichment or remedy) and by their greater diversity of software use (i.e. less reliance on drill-and-practice). But they were not as frequent computer users and two-thirds of them reported that non-users were engaged in seat work, a higher fraction even than less computer-experienced middle grade mathematics teachers.

In high school algebra and higher mathematics courses, activity patterns involving computers were quite different from those described for elementary, middle, and high school general mathematics classes. Use of computers in higher mathematics classes was much less frequent-even if we restrict consideration to only that algebra and higher mathematics classes that made some use of computers. Only 13% of the computer-using high-level mathematics classes reported using computers more than once per week compared to 63% of the computer-using high school general mathematics classes and a majority of lower grade mathematics classes.

Most computer-knowledgeable higher mathematics teachers (high-experienced and average-experienced teachers) were oriented to having students use computers in cooperative ways. In only 8% of their classes did students work on computers by themselves. Those teachers spent more time with students who were using computers, as opposed to working with the students who were not using them. And those teachers were much more likely to see computers as a regular part of the presentation of instructional materials in their class, as opposed to enrichment or remedy activity.

Interestingly, such high-experienced and average-experienced teachers also used computers less intensively than did the others using computers for the same subject. Only 9% reported using computes more than once per week. Overall, the major differences between algebra/higher mathematics classes and general mathematics classes in their use of computers were even more pronounced among the high school mathematics teachers who were most knowledgeable about computers.

The implementation of CAL for teaching mathematics has not always been a source of optimism for all school mathematics teachers. When teachers are faced with computers in mathematics classroom, many of them exhibit a high level of anxiety. "In fact, many times teachers exhibit more anxiety than their students" (Woodrow 1989). Actually many teachers are afraid of computer. Anxious teachers are also unlikely to seek computer training and are unlikely to welcome the push toward integrating computers across the curricula.

According to Woodrow (1989), only about 16% of teachers actually use educational computer applications. In addition, only 13% have received some training in computer applications, but are not yet in a position to apply this training. This result indicates that fully 70% of teachers have very little knowledge of computer applications and would require extensive in-service training to achieve computer literacy.

We have addressed the issues of teachers' beliefs and implementation of CAL. Now we will identify the teachers' roles and responsibilities in CAL environment.

IV. Teacher's Roles and Responsibilities in CAL

According to Heid et al. (1990), the teacher in the CAL classroom needs to begin class by describing a real life quantitative situation with the goal of inducing students to produce a viable mathematical model of the situation. The realistic nature of the problems naturally leads the discussion in a variety of directions as students suggest and argue the merits of several different mathematical models Teachers should encourage an open-ended exploration of real-world problems. But the length and content of class discussions are often unpredictable. So teachers need to know when and how to end these discussions.

Teachers should refine their skills at conducting classroom discussion, highlighting important points as they arise in the discussion, and summarizing discussion with any major point. Teachers should provide frequent feedback on students' progress on open-ended tasks. They should make specific suggestions to students on how to begin working with their partners, and should emphasize the need for suggestions as students become more able partners in the group process. They should encourage the spread of ideas and distribution of student expertise around the class. They need refined skill as a discussion leader and as a catalyst for self-directed student learning

In CAL environments, the teacher's role as facilitator expands to include working individually with the student helping to debug errors of procedures. They must provide assistance with the operation of the hardware and the techniques of using the software as well as with the problem solving itself.

As an assistant in the CAL classroom, the teacher not only must respond to a greater range of calls for help but also must be able to identify the nature of the problems that arise. For example, when a student asks for the teacher's help because he can not produce a correct graph, then the teacher-diagnostician must determine whether the cause is electrical failure, incorrect adjustment of the monitor, incorrect entry of the function rule, incorrect choice of scaling, or any of a variety of other electronic or conceptual problems. But just intervening to tell students a rule or an idea has little or no effect until students themselves see the need for these ideas. "It is no longer sufficient for the teacher to have a box of 'quick fixes' to dispense when an algorithm goes awry" (Heid et al. 1990).

Without interfering with the acceptable and natural evolution in a group's working style, the teacher needs to be facile at assessing the progress of students at the computer and at encouraging working arrangements that will enhance the process for each pair or group. The teacher also should be a consultant or collaborator, working with students to determine the truth of their conjectures.

Teachers should allow students the freedom to choose their own goals, to build up the self confidence to explore and try things out for themselves, because students need the freedom to test out their conjecture and to develop their own styles of learning. If the students are able to work at the computer within a non-competitive environment, then they have the confidence to try things out for themselves in an experimental manner (Heid et al. 1990). This type of mathematical environment encourages students to be actively involved in their own learning. Thus, teachers need to make the classroom a non-competitive environment when using computers for teaching mathematics.

We have discussed the teachers' roles and responsibilities in CAL. Finally, we will give some suggestions and a set of research directions to solve implementation problems in CAL. Some of them could be applied for in-service and pre-service teacher education.

V. Suggestions for Teachers and Research on Implementing CAL

Teachers' lack of knowledge in using computers for teaching mathematics make them psychologically reluctant to use computers in mathematics classroom. So teachers need to participate in workshops and courses that are related with CAL. The in-service teacher education program should provide a variety of computer software that is useful for teaching mathematics, for example, G.S.P., Spread Sheet, Algebra Xpresser, Logo, $\cdots$, and so on. Thus we need to do research not only on the teachers' knowledge on CAL but also on developing software.

Becker (1987) showed that elementary, middle, and high school teachers have different perspectives and beliefs on using computers, and they behave very differently. So, teachers need to discuss CAL with colleagues. However it can not easily happen in reality. Thus, we need research dealing with social interactions between teachers.

Computer technology has changed rapidly and it will change must faster than in the past. Teachers need to get along with the change not only to obtain new ideas but also to get new computer products for teaching mathematics. Thus, teachers should read professional journals and research studies that are related to CAL. We need research on how teachers react to journals and research studies that are related to CAL.

If teachers and researchers follow these suggestions, their efforts will be in vain without the school administrators' help, and without adequate funds for implementing the suggestions. Therefore, school administrators should provide adequate resources, time, and funds for teachers to participate in special programs for CAL. For the purpose of implementing CAL, joint efforts of teachers, school administrators and the government are required.

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