Computer Partner in the Classroom: Fostering Small Group Problem Solving

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Abstract

Designers of an anchored instruction approach to learning envision a cooperative learning environment where students can create a community of inquiry while solving complex problems. This approach "anchors" instruction in the context of meaningful problem solving environments, engaging both teachers and students in sustained exploration of a rich problem space [3]. Anchored instruction requires reevaluating classroom structure, communication dynamics, and the instructional artifacts used in the process. A major challenge for anchored instruction, and problem based learning curricula in general, is to help ensure that each student learns while also gaining the experience of working collaboratively. One possible solution involves integrating the computer as an active "agent" involved in the instructional process. This paper outlines a theoretical framework to define a learning environment that establishes the computer as a simultaneous partner for the teacher and the students and presents a computer program that employs this framework for use with students in a collaborative environment.

Keywords — anchored instruction, computer mediated instruction, problem solving, science education, small group collaboration.

1. Introduction

Anchored instruction and other problem based learning theories offer a rich context in which to explore methods of building collaboration by restructuring the classroom and integrating computer technology into the classroom discourse. The Cognition and Technology Group at Vanderbilt (CTGV) has explored a number of ways to enhance the potential of each student participating in a collaborative learning environment. The essence of the approach has been to devise situations that help make students' thinking visible to themselves as well as to their peers and teachers. Efforts to achieve this goal have lead to increased achievement and attitude gains [3].

2. Establishing a Partnership with Computers

Many researchers refer to computers as "cognitive tools" capable of amplifying or modifying cognitive ability. Salomon, Perkins and Globerson refer to cognitive effects as "effects *with* technology obtained during intellectual partnership with it, and effects *of* it in terms of the transferable cognitive residue that this partnership leaves behind in the form of better mastery of skills and strategies." They compare this partnership metaphor to a human partnership which includes: "(a) a complementary division of labor that (b) becomes interdependent and that (c) develops over time." [10]. How then does a partnership between an individual and technology manifest itself in relation to what goes on in a classroom? To answer this let us expand on these partnerships at the local level of computer/individual interaction, then discuss how to expand the partnership model to express the simultaneous dual partnership computer technology maintains with students and teachers in a classroom setting.

The first partnership between individual and technology, a systems view [7,9], includes the cognitive effects *with* the technology. The systems view teams the individual with the technology to form a joint intelligence which shares the labor during the cognitive process. This type of cognitive distribution manifests itself in two forms. First, the technology can serve as an amplification of an individual's own ability. Consider how a mechanical lever can amplify physical strength to move large objects; the lever cannot move the object without human intervention and the human cannot move it without the lever. An analogous technology/individual partnership includes an individual working with a spreadsheet on a computer. The individual can define the constraints of the problem and control the creative process as the computer performs the massive computations, permitting investigation of alternative solutions. The cognitive effect with this technology results in an amplification of the cognitive ability of the individual.

In the second partnership between computer and individual, an individual view, the computer functions as a method of scaffolding an individual's cognitive abilities. We assume that individuals have limited cognitive resources available for processing new information based on their previous experience and sensory input capability. The computer, with its self pacing, wide symbol system of representation, can provide a mechanism for organizing or presenting information so that the individual is affected by the interaction [5]. The computer can model how it finds information to instruct the user in the aspect of the task, or "off load" part of the cognitive process, allowing the user to focus cognitive resources elsewhere [6]. In principle, over time the user will develop the cognitive skills necessary to accomplish many of the cognitive processes demonstrated in the partnership.

3. Dual Role of the Computer

The traditional model of one teacher to many students is constrained by classroom size, structure and traditional instructional artifacts. A teacher must gear the classroom discussion to the mean ability level of the class to reach the largest number of students. Less competent students cannot fully participate and extremely skilled students may become bored. However, if we expand the partnership idea to include the simultaneous dual role of the computer, then a new definition of the classroom environment results in the computer closely integrated with the instructional process. Figure 1 illustrates how the "agents" in this learning environment work with each other to accomplish the activity of teaching and learning.

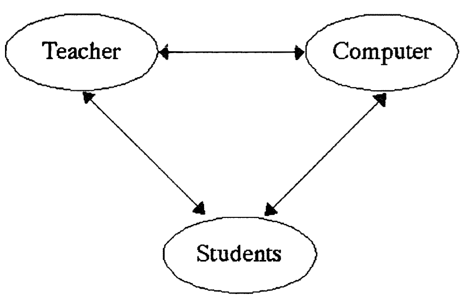

Figure 1. Teacher/Student/Computer triad.

The teacher/computer partnership utilizes the systems approach to introduce new concepts to students. The expressive power of the computer amplifies the teachers ability to instruct the class on a given domain topic. When students work in small groups, the instructional burden of mediating group dynamics is shared by the teacher and the computer. In this setting, students can receive some assistance to continue with their activity while the teacher assists other groups. The computer functions as an intelligent assistant that "understands" the instructional goals of the teacher and can provide feedback to the teacher. Feedback can be either synchronous with a small group activity or after the classroom meeting time in the form of a performance report. The end result is an instructional environment in which each computer assists the teacher in classroom activities with a common goal of instructing students.

The computer/student partnership can manifest itself from both perspectives. Traditionally, the "individual view" of students receiving assistance from the computer during drill and practice exercises, or even intelligent tutoring sessions, outside the class meeting time offers a disjointed presentation of information from the classroom presentation. In the dual model, the potential for deeper understanding may increase because of the strengths of sustained exploration of a given problem space and the benefits of shared expertise during whole class and small group discussions [8].

4. Inquiry in the Classroom

The dual partnership model of the classroom can be demonstrated by combining anchored instruction with computer mediated instruction. This section discusses the similarities and distinctions between two programs that combine anchored instruction and computer mediated instruction, the Computer Supported Intentional Learning Environment (CSILE) and a workstation environment, called QUEST, designed for use with small groups.

4.1. Anchored Instruction

Anchored instruction [3] provides a rich macro-context in which students and teachers explore possible solutions to problems. The problems may be posed through a variety of media; however, a video based format has proven to be a highly effective method of presentation [3]. The computer can easily be integrated into this "dialog" by assisting with the initial presentation of the problem and assisting the teacher in orchestrating the whole class or small group discussion. The computer can mediate the inquiry process by providing a set of tools to assist the group in understanding and solving the problem.

4.2. Whole Class Discourse Management

Computer Supported Intentional Learning Environment (CSILE) provides a general purpose environment to facilitate a discussion between class members through a network of computers. Students work individually or in small groups to generate and comment on solutions to problems posed by the teacher or other students. The teacher can use this environment to assess students understanding and guide the discussion to a deeper level. One of the strengths of this environment is its ability to keep a running history of the discourse. Students are encouraged to reflect on their own thoughts as well as those of others in the community. The result is a collaborative environment where students use each other as a resource for information and the teacher acts as a facilitator who guides students to a deeper understanding of a particular topic related to an anchor[11].

4.3. Facilitation of Small Group Discourse

Another method of supporting inquiry during anchored instruction focuses on small group interaction. The computer provides a level of scaffolding beyond structuring the classroom discourse through keyword structures. Instead of students sharing information across a network of computers, the students work in small groups in a self contained computer environment. The interface provides an impetus for discussion between group members by providing a set of resources to explore and collect information while attempting to solve an anchor. The following presents a specific example of how this instruction might be situated.

4.3.1. Questioning Environment to Support Thinking (QUEST)

The problem is posed using a video called the "Golden Statuette" [4] that depicts a modern day version of the Archimedes story. In this version a boy attempts to sell a lead statue painted gold to a metals dealer. The students must solve the problem of how much to pay for the statuette. The program provides tools for comprehending the video-based problem and investigating properties of the statuette [2]. In this environment students can experiment to construct the knowledge they need to solve the problem.

Identifying a problem is the first part of solving a problem [1]. The primary source for exploring the problem is through the anchoring medium; therefore, as shown in Figure 2, the students have direct access to the video based story in the form of a Quick Time (QT) movie stored on a CD-ROM. The students may use the standard scrolling bar beneath the video to review it for important information. The tool below the scrolling bar allows the students to create a "marker" for a specific range of the movie. With this tool they can label and save important data in the movie and quickly retrieve it through the list of markers in their notebook. This notebook, on the right in Figure 2, functions as a central collection resource for all the information the students generate and find during the inquiry process. The first goal is to describe in the notebook what is happening and what potential problems exist.

Once the problem has been defined and possible goals for solving it discussed, the students work with a set of tools to begin exploring properties of the statuette. Figure 3 illustrates the array of tools organized to provide students with a way to simultaneously view all the components of the problem solving process. The global problem, or goal, is posed at the top of the screen. The virtual laboratory area beneath the problem provides the tools used to obtain physical proper-

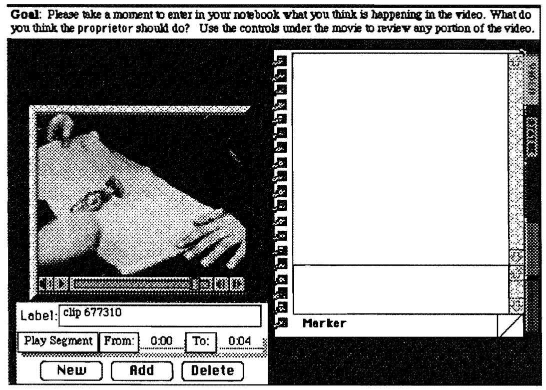

Figure 2. Problem posing/exploring screen.

ties of the statuette. As an example, Figure 3 shows the beaker tool with the statuette submersed. The process is fully animated to provide visual cues.

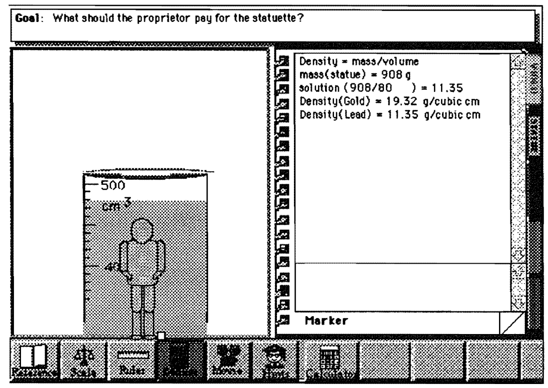

Figure 3. Beaker tool with statue submersed.

Other tools allow students to weigh and measure the dimensions of the statuette. Students can easily access a database of information including geometric relationships, physical properties of materials, price of materials and other scientific information using the reference tool. Students may browse through this information and copy any of its contents into their notebooks. A simple "click and drag" operation allows the students to move facts from the reference materials or measurement tools to the notebook. The electronic notebook provides a key feature to allow students to record what they feel is important, because they often forget to take notes. This feature helps students visualize the information they have mutually chosen as important. It also provides the teacher with a quick visual reference for where students are in the problem solving process. Therefore, the teacher can quickly assess and react to each group's individual needs. The collection and organization of these tools allows students to maintain a high level of exploration without being slowed down by collecting resource materials or recording information [6].

4.3.2. Hint Tool

The program allows students to ask for assistance as needed. The hint tool provides general assistance for using the tools and descriptions of basic science. More importantly the hint section presents a menu of "Things to think about..." questions that students might ask. Selecting one of these questions changes the focus from the statuette problem to a lesson that targets one of the important concepts needed to solve the problem. The students use the same set of tools to explore this new, more constrained goal posed in the lesson to gain insight into the applicable concept. Students can receive hints about the current problem, the statuette or lesson, each time they enter the hint section. These hints are scaffolded beginning with indirect questions to guide inquiry and progress to direct instruction. The design of this help section encourages students to assess their own thinking by deciding what type of help they need.

5. Pilot Testing

Initial pilot testing of the program revealed interesting qualitative results. A classroom of twenty-eight seventh grade students working in pairs attempted to solve the problem. With few exceptions, students expressed a preference for working collaboratively, generally in pairs. The level of dialogue between the students was very high, suggesting that the program will function well as a collaborative tool.

Students were motivated to solve the problem, as reflected by self reported measure called events that energize (ETE). Most students also indicated that they would like to work with similar tools in the future. The students' natural curiosity seemed to encourage them to explore all of the tools and to make use of the help section. Students indicated that they found the notebooks quite practical and effective for recording information. Preliminary analysis suggests that the environment may have a significant effect on post test results, especially on problems quite similar to that posed by the anchor.

6. Conclusion

In conclusion, designers of computer mediated instructional environments might consider this dual user function of the computer in a classroom setting. They should consider all the functionality a computer can provide not only to the immediate user of the technology, but also the other agents sharing the responsibility of instructing a whole class. Classroom environments using problem based learning methods like anchored instruction can benefit from computer technology that facilitates the collaboration between teacher and students and student to student. The end result is an environment that integrates the computer into classroom activities, increasing the potential for all students and the teacher to benefit from the partnership with the technology.

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