An Integrated Approach to Collaborative Electronic Learning

ALI R. REZAEI
California State University, Long Beach
USA
arezaei@csulb.edu

LARRY KATZ
University of Calgary
Canada

In this article, the authors introduce an Integrated Approach to science instruction with a focus on conceptual learning. The proposed Integrated Approach harmonizes three recently developed models of Learning. First, the Collaborative Electronic Learning (CEL) model that was shown to be an effective way of integrating technology into the physical and social science curriculum in elementary schools (Katz & Rezaei, 1999). Second, a teaching method developed by Mazur (1997) at Harvard University called the Peer Instruction Model (PIM) which improved student knowledge of physics concepts through mediated peer to peer interaction; and third, a conceptual change model, the Inventive Model (IM) developed by the authors (Rezaei & Katz, 1998) at the University of Calgary. The IM uses a computer assisted constructivist approach to deal with students' deeply seated misconceptions that obstruct learning. This article examines the models and proposes a research study which integrates CEL, PIM, and IM to examine the impact on learning using this Integrated Approach. Finally, an online course developed based on the “Integrated Approach” is introduced. The online course is currently being evaluated by the authors and the results will be published. The main goal of this article is not to introduce just another example of technology integration in science teaching, but to introduce a theoretical framework that could be customized based on the individual teacher's needs and objectives.
Modern learning theories incorporate the belief that knowledge is constructed by the learner through collaboration with the teacher and the peer group (Bruffe, 1993). Constructivist strategies are based on principles of learning derived from branches of cognitive science. They focus specifically on student motivation to learn and the ability to use what is learned in daily life. According to constructivism, knowledge is constructed by humans and is not a set of facts, concepts, or laws waiting to be discovered. These theories are based on the ideas of philosophers such as John Dewey, Jean Piaget, Thomas Kuhn, Lev Vygotsky, Jerome Bruner, and Ernst von Glasersfeld.

Multiple perspectives, authentic activities, and real-world environments are just some of the themes that are frequently associated with constructivist learning and teaching. According to the constructivist theory students learn by doing and learning is significantly influenced by collaborative work. (Shelly, Cashman, Gunter, & Gunter, 2002). However, true collaboration in schools requires well-designed learning activities based on sound principles of collaborative learning that are facilitated by technology where appropriate.

In a previous article, the authors introduced the Collaborative Electronic Learning (CEL) model as an effective way of integrating technology into the physical and social science curriculum in elementary schools (Katz & Rezaei, 1999). Although the focus in the initial research was not on conceptual science instruction, it was observed that collaboration helped students to critically challenge each other’s ideas and also test their own preconceptions. Therefore, it was concluded that CEL model could potentially be used for conceptual learning where students’ deeply seated misconceptions obstruct conceptual learning. In this article, the authors introduce the Integrative Approach that aims to examine CEL model in a more advanced level of science instruction focusing on conceptual learning. In the proposed approach, CEL model would be integrated with two recently developed models in science education: a teaching method developed by Mazur (1997) at Harvard University called the Peer Instruction Model (PIM); and a conceptual change model, the Inventive Model (IM) developed by the authors at the University of Calgary. The IM has been used successfully as a computer-assisted constructivist approach to rectify students’ deeply seated misconceptions (Rezaei & Katz, 2002). The PIM on the other hand, has been used as a collaborative framework both to reveal students’ conceptions and to teach science for conceptual understanding. This article first examines each of the three models (PIM, IM, and CEL) and then proposes a research study, which integrates them in order to examine the impact of the integrative approach on the learning of science. The authors anticipate the proposed Integrative Approach be used by teachers or educational software developers as
A theoretical framework that could be customized based on the individual teacher's needs and objectives.

Peer Instruction Model (PIM)

Mazur's (1997) PIM offers an interactive approach to teaching physics that actively involves a large and heterogeneous group of students in the learning process. According to Mazur, only exceptional lecturers are capable of holding students' attention for an entire lecture period. It is even more difficult to provide adequate opportunity for students to critically think through the arguments being developed.

In Mazur's approach, instead of presenting the level of detail covered in textbook or lecture notes, lectures consist of a number of short presentations on key points, each followed by a short conceptual test. An overhead projector is used to show the conceptual test. The teacher reads the question (usually multiple-choice) and then gives the students only one minute to select an answer and record their answer. Since each student is expected to answer individually, they are not allowed to talk to one another. Silence pervades the classroom. After the lapse of about a minute, each student is asked to try and "convince a classmate" of the rightness of that answer.

This process forces the students to think through the arguments being developed, and provides them and their teacher with a means of assessing their understanding of the concepts involved. The teacher always participates with a few students in the animated discussions that follow. After giving the students a few minutes to discuss the question, they are asked to record a revised answer. Then, an overhead projector is used to show the distribution of answers.

Usually, the results of the show-of-hands after the convince-your-neighbours discussion reveal an overwhelming majority of correct answers. The teacher therefore, spends only a few minutes explaining the correct answer before going on to the next topic. If most students choose the correct answer to the conceptual test, the lecture proceeds to the next topic. If the percentage of correct answers is too low (say, less than 90%), the lecture is slowed down to present the concept in more detail, and to reassess with another concept test. According to Mazur (1997), this repeat-when-necessary approach prevents a gulf from developing between the teacher's expectations and the students' understanding. A gulf that, once formed, only increases with time until the entire class is lost. One of the great advantages of the PIM is that the conceptual test answers provide immediate feedback on student understanding.
The drawback with this approach is that the conceptual tests follow a short lecture rather than a conceptual hands-on/minds-on activity. Mazur's method focuses on conceptual learning but is not a conceptual change model which can rectify deeply seated misconceptions. In his book, Mazur reported a significant increase in conceptual learning as a result of PIM (Mazur, 1997). However, no evidence of conceptual change is provided in the report. Conceptual change could be claimed only if students develop a coherent and integrated concept (e.g., Newton's laws of motion in this case). Although his reports of the show-of-hands after the "convince-your-neighbours" discussion reveal an overwhelming majority of correct answers this does not mean students' misconceptions have been rectified. Since students' initial conceptions are recorded only in their notebook the teacher will not be able to compare students' initial conception with their final conceptions.

Furthermore, students often display a level of "understanding" in standardized science tests or in teacher-made tests, which may give teachers a false sense of their students' true understanding (Mestre, 1994). These tests usually do not address students' misconceptions, but rather the students understanding of the material covered in class. More interestingly, students are able to solve conventional problems without understanding the underlying conceptions or without being able to correctly apply the concepts to real situations (Halloun & Hestenes, 1987; Trowbridge & McDermott, 1980).

The advantage of the PIM is that the convince-your-neighbour discussions break the unavoidable monotony of passive lecturing and, more importantly, the students do not merely assimilate the material presented to them. They must think for themselves and put their thoughts into words. However, this approach is mainly lecture-based and teacher-centred and there is not enough time for longer collaboration and discussion. Using the online after-class collaboration, found in the CEL model, may compensate for this limitation.

The other limitation of this approach is that the conceptual tests take more than one third of each lecture period, leaving less time for hands-on/minds-on activities. Mazur suggested two choices: (a) discuss in lectures, only part of the material to be covered over the span of the semester, or (b) reduce the number of topics covered during the semester. He himself chooses the first method. That is, he eliminated worked examples and nearly all derivations from his lectures. To make up for the omissions of these mechanical details, he required the students to read the textbook and his lecture notes before coming to class. In this way, students are exposed, over the length of the course, to the same amount of material taught in the conventional course.
However, there is no guarantee that students will read the textbook or the teachers’ notes before or after class. To increase the efficiency of the instruction, the teacher could also require students to work collaboratively after class using interactive online materials and simulations based on the IM (Rezaei & Katz, 1998). In this way, teachers could keep track of student performance and understanding even after they leave the classroom.

The Inventive Model

The IM is a constructivist approach to learning that focuses on conceptual change. It was developed as a theoretical model for science instruction, and particularly for software development in science education (Rezaei & Katz, 1998). Research findings consistently show that misconceptions are deeply seated and likely to remain after instruction, or even to resurface some weeks after students have displayed some initial understanding immediately following instruction (Halloun & Hestenes, 1985). Boyle and Maloney (1991) found that students’ misconceptions are so powerful that even if they had their textbooks open in front of them, only a few would be able to solve conceptual problems. For example, the misconception that the sun is closer to the earth in the summer than in the winter prevents students from understanding the scientific reasons why it is warmer in summer than it is in winter. Similarly, the misconception that upward moving objects have an upward-directed force acting on them prevents them from understanding Newton’s laws of motion. The reason is that the common sense conception is so powerful that it overshadows any explanation from the teacher.

The process of conceptual change is more complicated than it appears. Only a few conceptual change models have been reported to be effective (Posner, Strike, Hewson, & Gertzog, 1982). Research shows that instructional approaches that facilitate conceptual change are more effective than other approaches that disregard students’ cognitive structure (Mazur, 1997). However, teachers and educational software developers rarely build their instruction on a valid measure of students’ misconceptions. The instructional design used in the IM is based mainly on a longitudinal and systematic evaluation of students’ misconceptions.

Theoretically, the IM has four phases. In all phases, sophisticated computer simulations, animations, or videotaped experiments are used instead of real science experiments. Computer experimentation, that is, simulations in which students can vary parameters and make and test predictions, has a different role to play than real experimentation. Computer simulations allow a
comparison of student understanding with the accepted theoretical model. It has been repeatedly reported (Dekkers & Thijs, 1998) that classroom experiments are never fully convincing, since they can only be performed with imperfect results. It is almost impossible to eliminate the effects of the extraneous variables such as friction or air resistance in a real science experiment. The use of simulations is based on the constructivist idea that learners construct their own unique concepts through active participation.

Research has shown that computer simulations are invaluable teaching tools (Willett, Yamashita, & Anderson, 1983). They are also valuable in helping teachers design and conduct experiments that are supplementary to real experiments by allowing students to vary parameters that cannot easily be varied in a real laboratory. An important aspect of simulations is that the student is constantly active in answering questions, relating concepts to each other, solving problems, and making decisions. Using the new powerful multimedia computers, simulations are no longer unrealistic as claimed by some critics (Kulik, Kulik, & Cohen, 1980). McDermott (1984) observed that “the procedures the students used in typing to produce various motions in the computer environment closely resembled the procedures used by students in the laboratory investigations” (p. 30).

The first phase of the IM starts with a systematic analysis of students’ preconceptions. Although students’ conceptions are unique and private, most of their concepts are public (i.e., most students have similar misconceptions). Therefore, in the instructional design of the IM both kinds of misconceptions (unique and common) are addressed. The simulations and the videotaped experiments are developed based on the literature on students’ common misconceptions. However, feedback is offered based on each individual student’s answers to the conceptual questions. This is similar to the first phase of Mazur’s PIM. However, in the IM, the questions follow a conceptual hands-on/minds-on activity such as a simulation or a real experiment rather than a short lecture. Moreover, the questions are not limited to multiple-choice items. (Figure 1)

To save time, teachers use videotaped experiments or simulated experiments and students can reply (vote) simultaneously by using online format or personal digital assistants, which immediately record and tabulate their responses so that instructors have immediate feedback on students’ understanding.
The juggler is playing with six identical balls. At a particular instant, the balls are at the same height. The diagram shows the velocity vector for each ball at that instant as well as its trajectory. Which ball has the greatest force acting on it at this moment.

Type your answer here.

Figure 1. A screencapture of a conceptual question to evaluate students' misconception

In the second phase, advance organizers or other cognitive strategies such as, concept maps and/or analogies, are used to activate the students' prior knowledge and bridge it to the new concepts to be learned. For example, students see an animation showing the relative distance between the sun and the earth in the winter and in the summer. Both in this second phase and in the last phase, students' acceptable concepts are refined and reinforced in a guided discovery manner. This means that, if the majority of students have a deep misconception, teachers will move to the third phase processes to rectify the misconception. However, if the answers are close enough to the scientific conceptions, teachers can move directly to the fourth phase where they help students to refine their conceptions. It should be noted that the duration of a lesson based on this model varies from a few minutes to several weeks depending on the complexity and importance of the concept to be learned.

The third phase includes different activities, such as having students:

1. Test their preconceptions through hands-on activities or computer-based simulations.
2. Compare their preconceptions with natural phenomena and related scientific theories and identify any conflicts between their misconceptions and the scientific theories.

3. Become dissatisfied with their misconceptions through a multi-perspective demonstration and problem-solving situation and feel the need for a new concept; or, explore plausible alternatives by themselves or as suggested by their classmates or the teacher, and choose the more convincing one.

In the fourth phase, the teachers explain the correct answer and demonstrate the advantages of the conceptions currently accepted by the science community through a multi-perspective demonstration. The teachers may also help students summarize what they have learned.

The basic rationale of the IM is the belief that conceptual change does not occur simply because students see a conflict between their preconceptions and the scientific realities; rather, students, after testing their preconceptions, will gradually realize the advantages of scientific explanations. This will happen only if the teachers and technology supply the required cognitive tools and provide a clear contrast between the student's conceptions and scientific conceptions through a variety of demonstrations.

The key factor in the IM is the multi-perspective presentation. The authors believe that generalizations based on a single experimental design might be misleading. However, considerable time is required to probe students' conceptions and to present new concepts from different perspectives through a variety of demonstrations. An effective way of dealing with the time limitations in formal science classrooms and many inquiry approaches including PIM is to empower the instruction and the inquiry processes by using computers.

The following is an example of how the IM is translated into practice. A very common misconception among students concerns the relationship between force and motion. Many students believe that if there is a force, then there is a motion, if no force, then no motion (Dykstra, Boyle, & Monarch, 1992). For instance, they cannot realize that an object might be moving without any forces exerted upon it. Even harder to understand is the fact that an object might be moving in the opposite direction of the force being exerted upon it at that moment.

The first step in the IM is to analyze students' misconceptions. This phase could be done by the teacher even before the class starts through reading literature on students' misconceptions in a particular concept. However, many teachers prefer to do their own analysis in class through hands-on activities followed by conceptual questions. In a lesson based on the IM, students
interact with a simulation or interactive video that addresses a particular misconception. For example, students watch an athlete throwing a ball upward into the air. They are asked to consider if any force is being exerted on the ball at the peak of the motion. If the answer is yes, then they are asked to identify the direction of the force by clicking on the computer screen. In another case, students see a spaceship moving in outer space, not close to any planet and with the engine off. They are asked to consider if there are any forces exerted on the spaceship. After several conceptual questions the teacher will be able to see how prevalent the misconception is.

In practice, the teacher’s plan to rectify students’ misconceptions starts in the second phase. This could not be done without actively involving students with hands-on activities or interactive simulations prepared to help students to move toward scientific conceptions. However, teachers should note that there are several steps between the misconception and the scientific conception. These steps are similar to those that have taken place in the history of science among scientists. Therefore, the teachers cannot take students directly from the first step to the final step. For example, in a second step the teacher could help students to realize that the more the force, the more the acceleration, and if force remains constant, the acceleration (not the velocity) remains constant. Again, this step could be done using interactive videos, computer simulations, or hands-on activities. For instance, students see a video of two people pushing a car while the amount of their force on the car and the distance and time, being shown on the screen. The students can stop the motion to collect the data at any time. Later, they see four people pushing the same car which doubles the force exerted on the car. In this way, the students collect enough data to measure the relationship between force and acceleration.

After several similar experimentations, students are ready to modify their initial conception to the one that is closer to scientific conception. Therefore, the next target conception will be something like: “if net force remains constant, there will be acceleration; if no net force, there is a constant velocity; no net force, no motion”. The authors have created a simulation of a gun being shot on the earth, on the moon, and in outer space. Students are able to change the initial velocity of the bullet and also the gravity force to explore the speed and the direction of the motion of the bullet in these three scenarios. In another case, students watch a video of a ball swinging in a circular motion on the end of a string. They are asked to select the path that they think the ball will follow after the string is cut. They are then asked to explain the direction of any forces exerted on the ball along the selected path.

During these processes, the teacher asks several conceptual questions to make sure students are on the right track. If not, the teacher provides them
with lower-level conceptions such as the difference between velocity, speed, and acceleration.

The scientific (Newton's) conception of the relationship between force and movement is the final target of our example (i.e., there is a net force if there is acceleration, but no net force if there is no acceleration). Again students interact with a variety of simulations or real experiments targeting the final conception. For instance, students watch an athlete jumping on a trampoline or throwing a bowling ball on a trampoline. It should be noted that the key point here is students' active involvement in these processes. They do not passively watch these videos or simulations. For example, in the case of the athlete jumping on a trampoline, students should answer at least 20 conceptual questions before they go to the next simulation.

Rezaei (1999) developed a multimedia physics program based on the IM as a practical way to achieve this goal. The results of the study on its effectiveness showed that using a three-hour computer program based on this model was as effective as 16 hours of conventional physics teaching (Rezaei, 1999). In terms of rectifying students' misconceptions, it was found that the model was effective for more than 50% of the students (Rezaei, 1999). It should be noted that the IM has not been tested in a collaborative manner. The main goal of the proposed project is to test it in a collaborative environment similar to PIM or CEL.

Collaborative Electronic Learning

Educational research suggests that students who become involved with what they study learn more than those who receive information passively. There is wide agreement among reviewers of the collaborative learning literature that collaborative methods have a positive effect on students' achievement in almost any discipline (Brandt & Ellsworth, 1996; Lee, 1995; Totten, Sills, Digby, & Russ, 1994). Collaborative learning procedures have proven to be more effective than traditional instructional methods for student learning and the academic achievement process (Leung & Chung, 1997). Various theorists from Vygotsky (1986) to the situated learning theorists (Lave & Wenger, 1991) and to the current social constructivist theorists (Baker & Piburn, 1997) have also stressed the importance of social interaction to learning.

The CEL project (Katz & Rezaei 1999) was designed to integrate technology into collaborative science learning by building multi-school, interactive, learning environments through electronic communication. CEL model has been used to encourage collaboration and increase motivation.
An Integrated Approach to Collaborative Electronic Learning

To date, CEL project has been implemented in three phases. Two forms of communication were used in all three phases: synchronous and asynchronous. Synchronous communication allowed students to create an immediate dialogue of comment and response. Asynchronous communication included e-mail and electronic bulletin board systems where comments or questions were sent and students waited until the recipient read and responded to the message. Students’ verbal communications were videotaped and their electronic communications were saved in a database for further analysis by the researchers.

Phase one of CEL project included collaborative research in environmental science followed by collaborative electronic development of research reports and the reporting of the results in a synchronous videoconference. Onsite observations, field experiments, and materials garnered through Internet searches were shared. Onsite data collected through interviews and surveys were incorporated into a collaborative report that examined each issue identified by student groups. Student collaboration used inexpensive technologies such as a telephone-bridge, NetMeeting™ Netscape™ First-Class™ and Smart Board™ High speed Internet was also used to increase communication speed.

Phase two, focused on “Designing the Urban Community of the Future” using SimCity 2000™ software and collaborating over distance, again using collaborative report writing and synchronous video conferencing. The main feature of SimCity 2000 for students is to design, manage, and maintain the city of their dreams. The students worked through an elaborate process to collaboratively design innovative urban communities. In community design, student teams were asked to create an ideal community. To accomplish this, the module was divided into two broad parts. In Part One, students were given a general overview of community structure as expressed though its different community systems such as transportation, health care, water resources, or land-use planning. Teams were then asked to choose one of these systems as a research topic. Teams then used electronic and other resources to become subject matter experts in their topic. Each team shared its results using the project bulletin board. In Part Two, teams designed collaboratively a graphic representation of their ideal community. In the final evaluation, teams were questioned about their project and were given opportunities to talk about their design preferences. The projects were judged on the basis of their internal integrity—that is, does the design work?

Similarly, in phase three, students collaboratively produced and presented TV newscasts about life at their school and in their community.

In all three phases, the teachers were merely facilitators, and not directors. They were careful not to participate directly in students’ discussions.
and decisions. It was concluded that the CEL environment created a kind of excitement, motivation, and collaboration that their teachers had not observed before. Knowing that their ideas or their products were going to be seen and evaluated by students from other schools appeared to have influenced the students to work harder and strive for excellence in their assignments. Furthermore, it was observed that the collaboration helped students to critically challenge each other’s ideas and also to test their own preconceptions. The use of electronic communication instead of face-to-face communication appeared to be useful for shy students or those with low self-confidence who, according to their teachers, rarely participated in classroom discussions.

The Proposed Project Using the Integrated Approach

The Integrated Approach combines the PIM, CEL and the IM. Peer group discussion is an effective way for many students to develop their conceptual frameworks and to learn problem-solving skills as they try out their own ideas on other students and the instructor. The theoretical basis for this position is inspired in large measure by the work of Vygotsky (1978). Vygotsky asserted the significance of dialogue as a tool through which individuals collectively, or individually, could negotiate conceptual change. In his experiments, Vygotsky studied the difference between the student’s reasoning when working independently and when working with an adult. The give-and-take of technical discussion sharpens critical thinking skills and helps students to overcome their misconceptions. Classes in which students participate in discussion force them to go beyond merely plugging numbers into formulas or memorizing terms (National Research Council, 1997).

In the proposed Integrated Approach, elements of the PIM and the IM are employed by using the technology as it was employed in the CEL project. As mentioned earlier, the drawback with PIM is that it is basically a lecture-based approach. The conceptual tests take more than one third of each lecture period, leaving less time for hands-on/minds-on activities. To address this limitation, the Integrated Approach will use interactive computer modules instead of real hands-on activities and consequently provide more time for dialogue and discussions.

Similar to PIM, lectures should consist of a number of short presentations on key points, each followed by a short conceptual test. A computer or an overhead projector should be used to show the conceptual test. In order to save time, especially with the convince-your-neighbour phase, computer-based modules from the IM would be used to enhance instruction. These
modules are specifically designed to address students’ misconceptions and have proven highly effective.

Instead of the lecture and the mechanical voting system used by Mazur, computer-based labs or simulations and students’ personal digital assistants (e.g., Palm Pilot™ or the online voting available on individual student’s computers could be used by students to answer the conceptual questions. In the Mazur’s model the teacher participates only with a few students in the discussions that follow. However, the proposed Integrative Approach allows the teacher to assess the mistakes being made by most students and to hear how students who have the right answer explain their reasoning. In other words, the Integrated Approach allows for “convince the teacher and the whole class” rather than “convince your neighbour” used in PIM.

The second limitation of PIM is that in the “show-of-hands” activity some students may not think enough about the questions and just copy from their higher-achiever classmates. In a computer-assisted environment, students can answer the teacher’s question anonymously if desired. In the Integrated Approach, students will have access to computers and therefore, they will have the opportunity to answer teachers’ questions simultaneously and anonymously which reduces the need and likelihood of copying the answers of others. The teachers would show the results only after everybody has answered. In this way, all students have to think about the conceptual questions. Moreover, when students use personal digital assistants, it is possible for teachers receive instant feedback on student progress and understanding. With virtually instantaneous access to cumulative data, the instructor can make timely decisions on how to proceed and get an insight into the confidence their students have in their understanding of the material.

Unlike the individualized version of the IM, in the Integrated Approach, teachers should have a more active role. Students would do the simulated experiments collaboratively under the teachers’ supervision. The teachers helps students (in a guided discovery manner) to interact with the modules in a meaningful way and to find the answer. The use of simulations instead of real hands-on activities saves a lot of time for more collaboration and demonstration. Finally, similar to PIM, the teachers re-ask the conceptual question and students should answer again, but this time, hopefully with a more informed answer.

The other limitation of the IM, as described earlier, is that it is basically a self-paced approach. In other words, there is no room for collaboration. On the contrary, there are some opportunities for students in PIM to have some conversations on the questions raised by the teacher. However, the problem is that, even in the PIM approach, not all students participate in the discussions. Experienced teachers in the field of collaborative learning know
that only a few students usually participate in discussions and the majority remains silent.

Experience with the CEL project revealed that the proper use of communication technology with a well-planned instructional design, increases class participation in discussions. The anonymous-user nature of the Internet allows all students to be brought into a community of communicating peers. Gradually, students are encouraged to express themselves, reveal their conceptions, and to share their thoughts publicly.

Simple, inexpensive, and commercially available technologies can be used for synchronous and asynchronous discussions. In PIM, the focus is on face-to-face discussions in small groups without using the communication technology. However, the advantage of using electronic communication over face-to-face communication is that it provides immediate and accurate feedback, and should result in higher participation rates.

The teacher's computer can collect, collate, summarize, and present to the class, overall performance as well as unique ideas and misconceptions. Furthermore, students should be able to continue their discussions even after class time. Students could also expand their discussions based on their interactions with online simulations provided by their teachers.

The other advantage of using electronic communication over the face-to-face conversation is that the dialogues could be saved and forwarded to the teacher or a researcher for further investigation, enabling teachers to evaluate students' preconceptions. Students' discussions on scientific concepts are very important research resources. Teacher-student talk and student-student talk have quite different characteristics. The student's role in teacher-student talking is often one of mere respondent, where the exercise tends to be more related to "finding out what the teacher wants to hear" than to any pursuit of understanding. Student-student talk on the other hand is based on an equal status and therefore, any idea can be intellectually challenged. Student-student talk often lacks the eliciting and reformulating features of teacher-student talk, but it has its own distinctive features.

Lack of interest and, perhaps, lack of a good background in science, has caused a great decline in North American students' enrolment in science related fields at the undergraduate and, in particular, graduate levels (Halpern, 1992). The earlier integration of technology into science instruction has not greatly improved the situation. The quality of educational software, particularly for the purpose of conceptual learning, has been the subject of many studies since the early 1980s (Roth & Petty, 1988). According to the literature, there are many reasons for the low quality of educational software, including a lack of a theoretical model for the instructional design. Even if
teachers find good quality software, they often find it difficult to integrate it into their lesson plan. In other words, some parts of the software do not match the goals and objectives of the course. The proposed Integrated Approach has been developed to overcome this difficulty. An online first-year physics course has been developed based on the Integrated Approach (Laue & Rezaei, 2001). The software is available at: http://www.ucalgary.ca/MAP. This approach provides customized instruction for teachers. Teachers usually prefer to create their own instruction rather than using someone else’s design. This online navigation and arrangement tool provides modules instead of units of instruction. Therefore, teachers can easily select the modules that they want to use and arrange them in their own way. All modules are designed based on the IM. The online course is currently being evaluated by the authors and the results will be published. Funding for this research project has been approved by the Office of Learning Technologies, Human Resources Canada, and commenced in January, 2002.

SUMMARY AND CONCLUSION

The initial goal of CEL was to train students and teachers to use technology in a meaningful and effective way with the focus on problem-solving and technology skills. Initial results showed that the collaboration helped students to critically challenge each other’s ideas and also to test their own preconceptions. This challenge is considered to be a key factor in most conceptual change models.

In the Integrated Approach, teachers would integrate CEL, PIM, and IM by using customizable interactive software and creating a collaborative environment similar to PIM (i.e., in-class, teacher monitored collaboration) or similar to CEL (for student-centred collaboration). It is expected that the integration of these models will make it easier for teachers to teach and for students to learn.

In the proposed project, teachers will use PIM as their main teaching method. However, where deeply seated misconceptions are being addressed, teachers should consider using the IM to rectify misconceptions. Furthermore, the instruction should be empowered by using interactive computer-based resources (e.g., simulations and interactive units) either online or through CD-ROMs. As part of the process, students will work collaboratively on their assignments both in class and after class using the technologies similar to those used in the CEL project.
Two types of resources will be developed and made available to teachers: (a) resources that allow teachers to customize the material, and (b) sequential modules that are pre-organized and targeted at specific student misconceptions. This has already been done for some physics units previously described. In addition to assessing the impact of the Integrated Approach, one of the objectives of the proposed research project is to compare the effectiveness of sequential versus customizable resources.

References


