INTERACTIVE LEARNING OBJECTS FOR FUTURE TEACHERS

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Introduction

The National Council of Teachers of Mathematics (NCTM) [1] recommends that the processes of representing and communicating mathematics be an integral part of teaching and learning mathematics at the K-12 level. These are two of the five process standards recommended in their Principles and Standards in School Mathematics (PSSM) text. This focus emphasizes the use of multiple representations of a concept to help students acquire conceptual understanding as well as the ability to communicate about the concept through multiple methods.

Richard Lesh [2] developed a translational model for learning mathematics that focuses on five modes of communication and knowledge construction. These processes of pictures, spoken symbols, manipulative aids, real-world situations, and written symbols and the translations between, and within modes facilitates mathematical understanding.

Since the Tulane Mathematics Conference in 1986 [3], undergraduate mathematics instruction has focused on multiple representations and communication in the teaching and learning of mathematics [4]. As we prepare future teachers of school mathematics, conceptual understanding of mathematics, representations and connections are an important focus of their preparation to teach mathematics. The PRAXIS Wisconsin Project incorporates the use of technology to assist future teachers in learning mathematics by the use of multiple representations to communicate about mathematical concepts in the process of solving problems. Faculty-led student teams of undergraduate education majors developed learning objects based on multiple modes of communication using multiple representations. The learning objects are interactive web-based materials, located in a central database on the web, accessible to future and current teachers.

Team Setup

This project was supported by the UW System PK-16 Initiatives and Curricular Redesign, the Academic ADL Co-Lab, and the UW System Office of Professional and Instructional Development under the original direction of Robert Hoar. This paper explores the University of Wisconsin – River Falls Model for developing electronic learning objects by undergraduate teams funded as part of this state wide initiative.

Each university involved in the PRAXIS Wisconsin Project was allowed to choose their own way of setting up their teams and achieving the goal of the project. At the

University of Wisconsin – River Falls, we chose a different methodology than any of the other campuses. We selected students that were at least three years into their mathematics education program and had some practicum experience before going out to student teach. Each semester we have included three to four of these students as our student experts for the project. Over the past two years we have worked with nine different student experts on the project. We felt by choosing from this group of students, they would bring a greater sense of approaching the project from a teacher standpoint, rather than simply from a student perspective. We also felt this would be an additional experience that will help shape their teaching philosophy and ideologies once they begin their career.

Development of Learning Objects

Student experts were each given at least one problem from a list of released PRAXIS II – Middle School Mathematics items or released items from the Trends in Mathematics and Science Studies (TIMSS) exam. Student experts were often given a choice of what type of problem they would like to work on, selected from different content strands such as: geometry, number and operation, and statistics. Once the problems were selected, each team member attempted to solve her/his problem as well as each other's problems. This was done to make sure the content was clear to them, and to see whether those in the student expert group would solve the problem through different approaches.

The team reconvened to share their solutions and different approaches to solving. Once the group expressed their thoughts on the problem, they watched videos of student interviews that took place between one of the faculty advisers and a novice student. Multiple novice students were interviewed each semester and were selected from a pool of students enrolled in one of our general education mathematics courses. Since the beginning of the project, we have interviewed twenty novice students. Students selected for the interview consented to being videotaped, as well as to have their videotaped interview shared with the student team. The utilization of videos of novice student problem solving interviews was unique to our campus model.

During the course of the interview, the faculty adviser would ask the novice students the same questions that the student expert team was working on. The novice students were asked to not only write out their solutions to the problem, but to also present their thought process for solving the problem. If the novice student did not verbally express their thought process, then it was the job of the interviewer to encourage them to do so. It was interesting and important to hear from the novice students why they chose a given solution as well as why they may have eliminated a given solution from consideration.

The interviews with the novice students were very eye-opening experiences to the student expert team. Many times, the novice students exhibited thought processes that the experts did not expect a student to have with the given problems. By giving the student experts an opportunity to not only see, but to hear from the novice students, they were better able to incorporate hints and ideas into their learning objects which would benefit the students using the objects in the future.

One example of a misconception that became evident from the interviews was when the novice students were asked to answer a ratio and proportion problem involving tagged snails in a population compared to total snails in the population. Based on the size of the given numbers, the students did not think any of the possible answer choices were correct, since they were much larger than the other numbers involved in the proportion. To alleviate some of this confusion, our student expert created a slide in her learning object that involved what looked like an infinite number of total snails to convey to the user that there was the possibility of a vast number of snails in the population.

Components of the Learning Object

Once the student experts had a solid understanding of how to solve their problem, as well as an understanding of common misconceptions, they were ready to create their learning object. The process would begin with the student expert making a story board in power point, which began with their initial problem. Each learning object was then broken into five components: initial problem with a hint, a sandbox, a tutorial, a chalk talk, and additional practice problems. Every learning object includes each component, as they all play a different role in improving the eventual users' understanding of the mathematics. Once the user opens the learning object on a web browser, it is at her/his discretion which component they want to work with. A user is allowed to click on each component's tab, thus they are not limited to using the learning object in strictly a linear fashion.

When a learning object is first opened, the user will see the initial multiple choice practice item as shown in Figure 1. The student experts created comments for each of the incorrect choices to give the user an understanding of why an incorrect choice was wrong if selected. The student expert also wrote a hint, which can be accessed by the user.

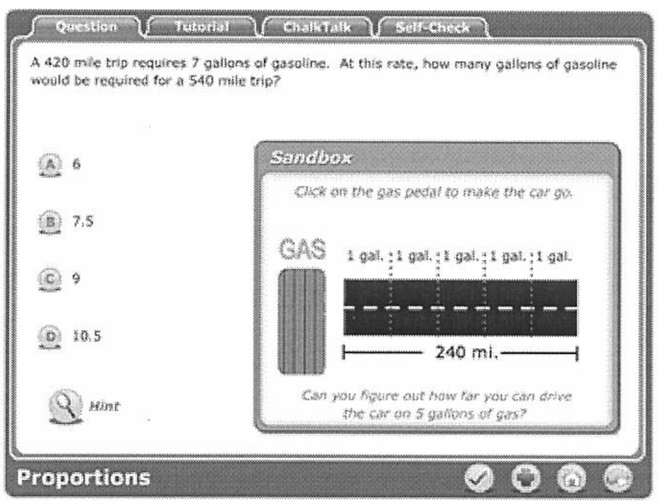

Figure 1

The sandbox, also shown in Figure 1, is a second component the student experts created. This was often the highlight of the process for our student experts. The sandbox is an interactive dynamical example, programmed in flash, which coincides with the question presented to the user. The role of the sandbox is that of a virtual manipulative where the user may explore mathematical ideas about the situation presented in the problem. In the example learning object shown in Figure 1, the user presses on the gas pedal to make an interactive car move along the road. The user uses this to help them gather information as to how far the car will travel while using each gallon of gas.

The next component of the learning object is the tutorial. As the student experts went through the learning stage of becoming familiar with their problem, as well as difficulties that novices would encounter with the problem, we encouraged them to present multiple solution paths for solving the problem. The tutorial is an exclusively visual representation of one of those solution paths created by our student expert. A static story board was created in power point, which represented a slide show demonstrating to a novice how to solve the problem. Once the story board was approved by the team, it was sent to the flash programmer so it could be coded in flash and presented in a dynamical form which allows the user to watch individual parts of the story, at their own pace. The presentation of the story board was done in a linear fashion, but it is up to the user how long they want to spend on each part of the story, as well as if they would like to return back to a previously presented part of the story.

The fourth component of the learning object is the chalk talk. This is similar to the tutorial component, but it is presented to the user in both an audio and a video representation. Each of the student experts wrote a script for the chalk talk, which explains a second solution path for solving the original problem. The goal was to present the user with a secondary approach, in case the first one did not make sense to them. Once the scripts were written, either the student expert or a faculty adviser would make and produce a podcast of the problem.

A tablet PC, a microphone headset, and Camtasia software were used to create the audio-visual production. As the expert or faculty member wrote on the screen in digital ink, they were also heard expressing the thought process behind what it was they were writing. This allows the user to not only visualize the process, but to also hear about it too. The chalk talks were produced as movies, and range in length from one to five minutes. Users would have the option of pausing and rewinding it at their leisure until they were able to understand what was being expressed by the chalk talk. See Figures 2 and 3 for examples of the visual aspect of the Chalk Talk of another ratio and proportion problem involving measurement.

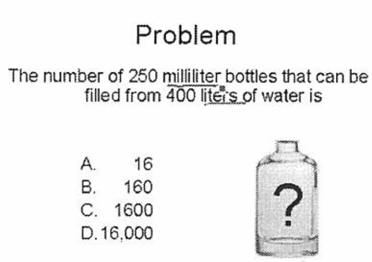

Figure 2

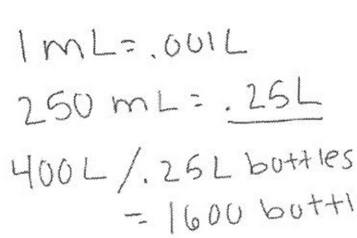

Figure 3

The final component of the learning object is a place for the user to practice what they learned or better understood by completing the other components of the learning object. Each student expert was required to produce ten additional problems, similar in nature and addressing the same concept as the original problem. Depending on the format of the original question, some of the practice problems were very creative with different contexts presented, while some may have simply been a minor modification.

Conclusion

As we conclude our second full year of participating in the PRAXIS project, we reflect on the positive effects it has had on us and our students.

Our students gained valuable experience in creating curriculum materials, insight into multiple approaches, and addressing student misconceptions with mathematics. As faculty mentors of undergraduate research, this is the first time that we worked with undergraduate research teams rather than as research advisors on individual research projects. There is an interesting dynamic that occurs in a research community of undergraduates accomplishing projects collaboratively. This collaborative experience will be beneficial for the students as they begin their teaching careers.

One byproduct of participating in the project is our eventual inclusion of a tablet PC into our own classroom. Since we were required by the project to learn to use the tablet PC to produce the chalk talks, we have also used it in our own teaching. The tablet PC has been used in class as the primary medium for producing notes and activities, rather than using a chalkboard. It has also been used to create podcasts for our students in our classes, using the same premise as the chalk talks for the project. This process has led to a new vision of virtual office hours as well as new ways to provide audio and video feedback on student projects through podcasting.

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