Abstract
In recent years, a Liberal Arts Math course has been significantly restructured to encourage and support the many students with math anxiety, with technology playing an integral role in this effort. Practical advice about the technology, data from student grades, survey data, and some results from an administration of Tapia’s Attitudes Toward Mathematics Inventory are provided.

Introduction
Beginning mathematics courses pose many distinct challenges for teachers. To an instructor it seems that many students, particularly in basic or liberal arts courses, have a pessimistic view of mathematics. These classes can be filled with apathy, anxiety, and poor motivation. Many students in these courses do not see the significance or utility of mathematics. How does a teacher overcome these obstacles?

One method of motivation is to use technology to engage students inside and outside of the classroom. At West Virginia University, course coordinators in the Institute for Math Learning (IML) are using this idea to reinvent courses at the calculus level and below. These courses have been targeted for inclusion in the IML because of historically large numbers of students receiving a D, an F, or withdrawing. The courses have been restructured to include PowerPoint lectures, interactive weekly computer laboratory activities, weekly online homework quizzes, and active lectures using a Personal Response System. The focus of this paper will be on efforts using the above technology in the Liberal Arts Math course, and students’ reactions to these changes.

Liberal Arts Math is the course typically taken by students with majors such as English, history, philosophy, journalism, and creative arts. In order to gauge attitudes toward mathematics, students in this course were given the Attitudes Toward Mathematics Inventory (ATMI) (Tapia, 1996) at the beginning of the Spring 2005 semester. Results from survey were upsetting but not surprising. For example, almost 60% of students said that mathematics was one of their most dreaded subjects. Furthermore, over 60% of students communicated that they will avoid taking math classes whenever possible. For more information on the ATMI survey results, please see Butler and Butler (2007).
Technology in the Course

WebCT

In Liberal Arts Math, WebCT is used for exams, quizzes, general course information (such as the course syllabus), laboratory assignments, and tracking of student grades. The decision to use WebCT for course management was made for many reasons. Hargis (2000) states that the internet can help provide greater access to education. Since West Virginia University serves a largely rural population, this aspect of a course management system is considered especially important. Furthermore, Hargis (2000) and Vidakovic, Bevis, and Alexander (2003) note that the internet gives students an opportunity to review their work and individualize their study based on their mistakes. With exams, homework quizzes, and laboratories online, students are given the ability to control their studies.

Online WebCT homework quizzes are considered an especially important aspect of the course. The effects of online homework systems in mathematics classes are reported in, for example, LaRose and Megginson (2003), Hauk, Power, Safer, and Segalla (2004), Hirsch and Weibel (2003), and Suzuki (2003). In particular, Hirsch and Weibel (2003) studied the effect of calculus WeBWorK homework assignments. They found that students who used the online system showed a statistically significant improvement on a common final exam, and those students who attempted every WeBWorK homework problem had higher grades on the final exam by at least two letters. Caldwell (1999) points out that one of the main reasons for homework is to provide students with feedback so they can improve. For this reason, students may take each homework quiz up to three times and their best score is counted. With sections of 200 students, multiple attempts on homework would be intractable without an online system.

Furthermore, as Ponomarenko (2003) notes, a drawback of traditional homework assignments is that students often do not get any feedback until long after the assignment is completed. With WebCT homework quizzes, students are provided with immediate feedback on their performance. Students are encouraged to print quiz attempts and take them to a tutoring center, instructor office hours, or class for guidance that can be used on future attempts. In addition, the National Council of Teachers of Mathematics Standards (2000) advises continued assessment throughout a course, which Liberal Arts Math students receive through homework quizzes.

Finally, much work is being done to increase the engagement of students with course material in the class. To master material, however, students need to be engaged with material outside of class. Butler and Zerr (2005) give evidence that online homework quizzes increase outside-of-class student engagement.

PowerPoint Lectures
PowerPoint slides have been written to guide lectures in the restructured course. These slides are made available on WebCT, and students are strongly encouraged to print and bring them to class. It is hoped that it is easier for students to pay attention and focus on understanding the material without the worry of taking detailed notes. Furthermore, the slides are designed to help students focus on important course material, hopefully making them feel less overwhelmed. There was some concern that students would not attend class if they were given the PowerPoint slides ahead of time. Based on unpublished survey data from other IML courses which do not make slides available, this concern does not seem to be the case.

Laboratory Activities
Throughout the class there are 10 computer laboratory assignments, intended to engage the students in constructivist learning activities. These assignments take material from the course and extend it to new situations and applications. IML faculty members believe that using constructivist strategies is critical to engaging students in the course and helping to address poor attitudes. In particular, Hinde and Kovac (2001) offer evidence that such projects do result in more positive attitudes.

For example, students seem particularly enthusiastic about a laboratory linking math and the television show *The Simpsons*. Another popular lab is based on how statistics can be deceiving. Many of the labs use online java applets to explore the material in a hands-on way, and in each lab there is also an essay question on the topic. The labs are considered important for helping to engage students with different learning styles than are accommodated with other course components. Furthermore, demonstrating the utility of mathematics is a practical means of addressing the attitude issue.

Personal Response System
Students earn participation and attendance credit through using a Personal Response System (PRS). During lecture, students use PRS transmitters to answer multiple choice questions, and the PRS software records student responses. The instructor then displays the number of students choosing each answer, and discusses the question. After class, the instructor grades the student responses and uploads the scores to WebCT. Students can then use WebCT to track the participation points that they have earned throughout the course.

PRS questions are embedded in the PowerPoint slides. Since the PowerPoint presentations are available to students before class, the students are also able to read and think about the PRS questions ahead of time. This feature is considered helpful for students to prepare for class. On the course survey discussed in the next section, however, most students indicate that they did not think about the PRS questions before class.

PRS was introduced as a course component in an effort to increase in-class student engagement. There is support in the mathematics education literature that a PRS may be
well-suited to these goals. For example, Cutts, Kennedy, Mitchell, and Draper (2004) found that students using a PRS are essentially twice as likely to practice with examples in class. Additionally, Dufresne, Gerace, Mestre, and Leonard (2000) note that a PRS can inform teachers of gaps in student knowledge, with enough time to correct any errors. Furthermore, such a system allows the instructor to take into account what each student is thinking, prompting better interaction between students and instructor. It is then hoped that this will increase student motivation and improve attitudes toward mathematics.

**Student Response to the Course**

It is worth noting that 40% to 60% of students typically received a D, F, or withdrew (DFW) before the Liberal Arts Math course was restructured. Since the restructuring, the DFW rate has usually been between 30% and 40%. The goal is to continue to improve student success and achieve a DFW rate of less than 30%, while maintaining academic integrity.

During the Spring 2005 semester there were two sections of the course, which followed the same policies and procedures, and were both taught by the same senior instructor. At the end of the semester, students in both sections were given an anonymous survey asking their view of the various course components and integration of technology into the course. A total of 202 students participated in the survey. The course components discussed in the survey are PowerPoint lectures, homework quizzes, labs, and PRS. The survey was written by the course coordinator and first author, and read by two other faculty members in the Department of Mathematics to determine its validity for use in the course. Basic descriptive statistics for student responses and correlations among responses were calculated. This section will discuss significant findings from these studies.

On the survey, students responded to the statement “I thought the PowerPoint lectures where helpful in preparing for exams” on a Likert scale of 1 to 5, with 5 indicating “strongly agree.” A similar question was asked for each course component. Students responded most positively about the PowerPoint lectures ($M = 4.06, SD = 1.10$) and homework quizzes ($M = 4.11, SD = 1.14$). These survey questions on PowerPoint lectures and homework quizzes have a Pearson correlation coefficient of 0.306, which is significant at the 0.01 level (2 tailed). The labs ($M = 2.53, SD = 1.37$) and PRS questions ($M = 2.95, SD = 1.22$) were considered less helpful in preparing for exams.

Students also responded to the statement “I thought the PowerPoint slides were one of the most helpful aspects of the course” on the same scale. Again, a similar question was asked for each course component. The PowerPoint slides ($M = 3.86, SD = 1.15$) and homework quizzes ($M = 3.65, SD = 1.09$) were once more regarded as one of the most helpful aspects of the course. These survey questions on PowerPoint lectures and homework quizzes have a Pearson correlation coefficient of 0.207, which is significant at the 0.05 level (2 tailed). The labs ($M = 2.26, SD = 1.13$) and PRS questions ($M = 2.82,$
SD = 1.16) were considered less helpful course components. See the table for a summary of these findings.

[Table ONE]

The two survey questions discussed on PowerPoint lectures were found to have a Pearson correlation coefficient of 0.646 which is significant at the 0.01 level (2 tailed). The two survey questions discussed on homework quizzes were found to have a Pearson correlation coefficient of 0.763 which is significant at the 0.01 level (2 tailed).

On the survey, there was also space for students to make additional comments on each of the course components. Both authors read the responses and identified common idea blocks. One idea block in the comments about PowerPoint lectures was that the slides helped students follow the lecture. Other students, however, commented that the PowerPoint slides were not helpful because, as one student stated, “no good if you don’t have the teacher to explain.” Another student said that she preferred not to print out the PowerPoint slides, because she learns better by listening and writing the notes herself. Overall, the statistical data and student comments seem to support making the PowerPoint slides available online.

Many students commented that the online quizzes were useful in preparing for exams. Students also seemed to find it helpful to have multiple attempts. Both authors, however, found that another idea block in written comments about the quizzes was that some students did not like completing assessments on the computer.

In response to the laboratory assignments, many students felt that the labs were not related to material in class. Unfortunately, it is not possible at this time to have the students work on the labs during class time in a supervised computer lab, as is done in the other IML courses. In more recent semesters, instructors have spent additional class time talking about the lab assignments to help students see the connections with class material. In instructors’ opinions, this seems to have increased student satisfaction with the lab assignments. The lab activities are meant to be more challenging than the in-class material, and some students did like the added content. About the labs, one student said “they were more challenging than the quizzes – very good to have this before the test.”

Both authors found one idea block in student comments about PRS was that students found this technology frustrating. Furthermore, some students did not see a purpose in PRS questions, because they could just wait to see the correct answer. Other students, however, thought that PRS questions were very helpful. For example, one student thought that the PRS was the most helpful course component and wrote “PRS questions,
in my opinion, were the only problems that actually helped me because I could see why I got it wrong or right afterward.”

In the Spring 2005 semester, correlations between student scores on course components show that all were significantly correlated to each other, p < .01. Good correlations (r > .65) were found between final grade and lab average, exam average, and attendance. A moderate correlation was found between homework quiz average and lab average.

**Conclusion**
Overall, the authors believe that the technological components of Liberal Arts Math have improved the course. One limitation of the research presented in this paper is that, other than DFW rates, there is little data to compare the course before and after restructuring. Due to constraints in the university schedule, the students were not given a posttest on their attitudes toward mathematics. Future studies should be completed where both pre and post attitude surveys are administered and some form of technology is removed from a section of the course. Before that time more work should be done to integrate PRS questions and laboratory activities into the course, as suggested by student reactions to the technology. While the PowerPoint slides and homework quizzes can always be improved, it is believed that they are a successful part of the course. Furthermore, WebCT has become an integral part of managing the course.

This research could be applied to almost any university course in any discipline, and perhaps even secondary school classes. PRS, lab activities, and online quizzing with repeated attempts, are all course components that could be useful to any size class in any subject. WebCT, online quizzes, online exams, and PRS are components that can be especially useful in large classes.

It is important to continue researching the effects of the technology. One question that needs to be addressed is the ability of students with different learning styles to learn through the various course components. A second important research question is if the students would perform better, and feel more positively toward the course, if the laboratory activities were completed in a computer lab during class time. A matched pairs study on this question, in which students will complete both content and affective pretests and posttests, was completed in the Spring 2007 semester, and the data is still being analyzed.

**References**


