PRELIMINARY RESULTS OF THE EFFECTS OF INTERACTIVE COMPUTER LABS

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ABSTRACT
This paper details a research study on computer laboratory assignments designed for Liberal Arts Math. Preliminary results are mixed: students performed better on problem-solving assessments when given an opportunity to complete the assignments in a monitored setting, but performance was weaker on some course assessments. Statistical analyses are included.

INTRODUCTION
This paper details a research study on an interactive computer laboratory component in a Liberal Arts Math course at West Virginia University (WVU). Liberal Arts Math is the course typically taken by students whose majors do not require additional math courses. The course is not a prerequisite for any other courses, and is usually taken by students to fulfill the university’s math requirement.

At WVU, Liberal Arts Math, like most of the courses below the calculus level, is taught in sections with approximately 200 students. Because this large lecture environment presents unique challenges, a subset of the math department called the Institute for Math Learning (IML) is devoted to the development and management of these courses. A main goal of the IML is to improve the student learning and success in these large sectioned, lower-level math classes, through appropriate uses of technology. More information about how technology is employed in these courses can be found in Butler & Butler [1], Butler & Butler [4], and Butler, et al [5].

A weekly lab meeting, in which students complete interactive online-enhanced assignments, is a central aspect of this approach. The main purpose of the lab meetings is to allow the students to construct their own knowledge by exploring the material in a hands-on way. Significant resources have been devoted to developing lab activities and to the physical requirements necessary to host so many students in a computer lab environment. The rest of this paper gives preliminary results on a research study designed to help decide if such endeavors are worthwhile.

BACKGROUND
Since Liberal Arts Math is the only college-level math course that will be taken by a majority of the students enrolled, the material covered gives a broad exposure to many different math topics. One goal of the laboratory assignments is to demonstrate the applicability of these topics to everyday life. A second goal of the labs is to engage students with learning styles different from those which may be engaged with the lecture portion of the course. The lab assignments are completed on the WebCT or BlackBoard course management system, with links to other websites and java applets integrated throughout. Many of the questions are automatically graded. Essay questions are designed to be graded by a teaching assistant.

The labs in Liberal Arts Math evolved considerably over time, based on work with thousands of students. The labs were first piloted during the Fall 2004 and Spring 2005 semesters, at a time when every other IML course already had a fully developed lab component. These other IML courses also had weekly meetings in the computer lab, during which instructors and lab assistants helped students complete the laboratory assignments. Due to space constraints, students in Liberal Arts Math were unable to have weekly lab meetings in a computer lab. Instead, students were required to complete lab assignments on their own outside of class. Results from these first two semesters were poor. Performance on the labs was fairly weak and many students complained on course evaluations about having to complete these somewhat challenging assignments outside of class. Furthermore, students seemed to have difficulty seeing how the labs related to the material discussed during class.

These initial shortcomings motivated significant changes to the labs in the Fall 2005 semester. In addition, class time was specifically set aside to answer student questions, and refine student understanding about the labs. It is believed that the lab activities now fulfill the learning cycle based on work by Kolb and Kolb [11]: engage, explore, explain, and extend, which has been shown to improve learning [13].

Throughout the Spring 2006 semester, less successful labs were retired, new labs were introduced, and minor modifications to the various labs were made. A set of refined and revised labs was completed for the Fall 2007 semester. These labs were chosen to offer the students a good mix of applications, technology, hands-on computations, and development of problem solving skills. More information on the development of the labs, examples of the activities, student work samples, and survey results with student reactions to the labs can be found in [1].

LITERATURE BACKGROUND

In the research literature, there is much support for the constructivist approach to teaching mathematics that is used in the labs. For example, in Lord [14] a research study is reported where students in a constructivist classroom outperformed the students receiving traditional instruction. Other studies have supported this result showing that knowledge of concepts is best learned when a student discovers it on his own [9].

Research has also been conducted on the combination of interactive engagement strategies and computer resources. Kaput [10] reports on a research study where all students learned as well with computer manipulatives as with their hand-held counterparts, and some students were more successful with the computer system. Furthermore, an activity approach to science instruction has been proven to benefit students with learning problems ([8] and [15]).

The Liberal Arts Math lab assignments researched in this paper are similar to those described by Lahme, et al [12], which “…present practical problems that help change the
students’ flawed or narrow views of what mathematics is.” A major goal of the labs is to help students develop quantitative problem solving abilities. Research has shown that inquiry-based assignments help to improve students’ higher-order cognitive skills [17]. In addition, studies have shown that large lecture classrooms will have students with many different learning styles, so that one method of teaching is not sufficient to reach all learners [6]. Labs are a tool to help teach “a diverse student audience with varied mathematical background” [12].

The decision to use WebCT/BlackBoard for the lab assignments was made for many reasons. Caldwell [7] notes that the main purpose of homework is to provide students with formative feedback. On the other hand, Ponomarenko [16] remarks that a drawback of traditional homework assignments is that students often do not get any feedback until long after the assignment is completed. With BlackBoard labs, students are provided with immediate feedback on their performance. Other research on similar lab assignments is reported on in Butler [2].

METHOD

In Fall 2007, there were two sections of Liberal Arts Math taught by the same senior instructor. The two classes covered the same material in the same way, and completed the same assessments, except for the lab portion on the class. Thus, grading for the two classes was identical, expect for the 10% of the final grade that comprised the study.

One of the two sections was randomly chosen to be the Experimental Section, where students would have one class period a week in a computer laboratory where they would complete these inquiry-based lab activities. In a lab period, students worked on their own to complete lab assignments. They were offered guidance and help, but were not given the answers. The lab assignments comprised 10% of the final grade in the Experimental Section.

The other section was a control, where students would only meet in a lecture setting. In the Control Section, the instructor would lecture on the material covered in the lab. To earn the 10% of the grade that students in the Experimental Section earned through the labs, students in the Control Section completed worksheets during class based explicitly on the lecture.

PARTICIPANTS AND MEASURES

Participants in the study were all students who were enrolled in Liberal Arts Math in Fall 2007. Students chose which of two sections for which to register. In both sections, students who did not take the final exam for the course were not used in the study. The Experimental Section had 178 students. The Control Section had 169 students.

Students in both sections took the same test as a pre and post-measure. This test was specifically written for the course by the course coordinator and underwent extensive study before it was used in this research. A main goal of the test is to measure problem-solving ability. Course assessments were also used to compare the two sections, including the labs/worksheets, exams, quizzes, and attendance.

DATA ANALYSIS

To compare the groups, a one-way analysis of variance (ANOVA) was conducted on the course components. Table One shows the means and standard deviations by section. There was a significant difference between groups on Labs/Worksheets, F(1, 345) = 3.869, p < 0.001, with the Control Section (M = 92.46, SD = 13.54) outperforming the Experimental Section (M =
There were no other differences, significant at the p < 0.05 level, between the sections on the other course components.

Table One: Mean and Standard Deviations for Course Components by Section

<table>
<thead>
<tr>
<th>Component</th>
<th>Section</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quiz Average</td>
<td>Control</td>
<td>169</td>
<td>78.49</td>
<td>14.44</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>178</td>
<td>77.88</td>
<td>17.48</td>
<td></td>
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<tr>
<td>Exam Average</td>
<td>Control</td>
<td>169</td>
<td>71.70</td>
<td>13.10</td>
<td></td>
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<tr>
<td></td>
<td>Experimental</td>
<td>178</td>
<td>72.17</td>
<td>11.80</td>
<td></td>
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<tr>
<td>Final Exam</td>
<td>Control</td>
<td>169</td>
<td>68.33</td>
<td>13.39</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>178</td>
<td>67.61</td>
<td>13.47</td>
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<tr>
<td>Attendance</td>
<td>Control</td>
<td>169</td>
<td>76.97</td>
<td>21.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>178</td>
<td>74.76</td>
<td>22.52</td>
<td></td>
</tr>
<tr>
<td>Labs/Worksheets</td>
<td>Control</td>
<td>169</td>
<td>92.46</td>
<td>13.54</td>
<td>3.869*</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>178</td>
<td>87.60</td>
<td>11.05</td>
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<tr>
<td>Final Percentage</td>
<td>Control</td>
<td>169</td>
<td>76.38</td>
<td>10.33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>178</td>
<td>75.53</td>
<td>10.97</td>
<td></td>
</tr>
</tbody>
</table>

Note: One asterisk denotes a significance level of p < 0.001.

Based on the pretest scores, baseline differences existed between the sections prior to the intervention. For this reason, an Analysis of Covariance (ANCOVA) was conducted with a one-factor fixed-effect of Section, pretest as a covariate, and posttest as a dependent measure. Because of the large numbers of students who are enrolled in the classes each semester and the large numbers of students who withdraw or change sections of the class, approximately half of the students in each class did not take both the pre and posttests. In order to complete the ANCOVA, only those students who completed both the pre and posttest were used. In the Control Section, there were 90 students who completed both, while there were 91 students who completed both in the Experimental Section. Table Two shows the means and standard deviations for each Pre/Posttest administration by section.

Table Two: Means and Standard Deviations on the Pre/Posttest by Section

<table>
<thead>
<tr>
<th>Test</th>
<th>Section</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>Control</td>
<td>90</td>
<td>8.700</td>
<td>2.607</td>
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<tr>
<td></td>
<td>Experimental</td>
<td>91</td>
<td>9.802</td>
<td>2.663</td>
</tr>
<tr>
<td>Posttest</td>
<td>Control</td>
<td>90</td>
<td>9.033</td>
<td>3.667</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>91</td>
<td>11.362</td>
<td>2.567</td>
</tr>
</tbody>
</table>

On the ANCOVA analysis, there was a significant main effect of Section, F(1, 179) = 16.512, p < 0.0001, with students in the Experimental Section (M = 11.362, SD = 2.567) outperforming students in the Control Section (M = 9.033, SD = 3.667) on the posttest. The means, as adjusted by the ANCOVA analysis, were 11.090 for the Experimental Section and 9.308 for the Control Section. Table Three gives the ANCOVA for dependent variable computation.

Table Three: ANCOVA for Dependent Variable Computation

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
</table>

CONCLUSION

Data analysis shows that students in the Control Section performed better on the worksheets than students in the Experimental Section did on the corresponding labs. This result, however, is not surprising because students in the Control Section were given the answers to the worksheets as part of the lecture on the material. Students in the Experimental Section had a more challenging assignment to work individually on lab assignments to solve the problems; they were given help when needed, but were never told the answers. Thus, it seems important to note that the students in the Experimental Section still did relatively well on the labs.

While the researchers had hoped that the lab activities would have an impact on student retention of material, which would be evidenced on exams, this analysis does not support that conclusion. Further in-depth examination of item-by-item analysis of exam questions, as related to lab material, is planned. It was also hoped that the structure of lab meetings and assignments would have an effect on student motivation and that this would be evident by increased attendance and improved lab grades. Again, these analyses do not support that such an impact was achieved since there was no significant difference between the sections on attendance and the Control Section performed significantly better on the worksheets.

Thus, the analyses, as discussed so far, imply that the trouble and expense of a lab day may not be worth it. It is important, however, to consider another major goal of the labs, which was to improve student problem solving. For this research, student problem solving was measured by performance on the pre to posttest. The students in the Experimental Section, who had a lab day, improved more from pre to posttest than did the student in the Control Section. This evidence suggests that the interactive, problem solving approach used in laboratory-type activities may have some impact on the problem solving abilities of students. Hence, the effects of a designated lab period and lab assignments seem mixed, with some benefits and some drawbacks.

One obvious weakness in the study is that students were not randomly assigned to their sections. In an effort to control for this, additional research is planned that will employ a matched-pairs analysis. It will be interesting to see whether the current differences exist between the matched-pairs or if other differences emerge. Furthermore, additional studies should be conducted on the specific effects of the use of computer-aided activities in the labs.

REFERENCES


