College Algebra: An Overview of Program Change

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Abstract

This paper synthesizes results of several small research studies conducted in College Algebra at West Virginia University. Past and current research projects in the course are discussed and significant findings from each study are reported. References for full details on the studies are given. Findings include student change on an ACT pretest to posttest in the Fall 2004 semester, where it was found that all students gained an average of 1 scaled point. Other research described involves learning styles, PRS, and online quizzing.

KEYWORDS: technology, learning styles, mathematics, curriculum change and development

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West Virginia University (WVU) established the Institute for Math Learning (IML) within the Department of Mathematics in January 2001. The goal of the IML is to develop, evaluate, and implement new and successful approaches to mathematics teaching and learning. The IML was formed partly in response to results from the Third International Mathematics and Science Studies (TIMSS), which showed that the United States trailed most developed countries in the world on this assessment (Mullis et al., 1998). However, the IML also was established because in 1999-2000, the average math ACT score in West Virginia was 19, well below the national average of 20.7 (Average ACT Test Scores, 2000). Since many WVU students are behind in mathematics achievement both internationally and nationally, faculty members are developing and implementing new curricula and embracing new teaching strategies. More information about the IML can be found in Mayes et al., Mayes (2001), Mayes (2004), Butler & Butler (2006), and Butler & Butler (2006).

Through the course changes, faculty members have tracked the number of students receiving a D, an F, or withdrawing (called the DFW rate). Most IML courses historically had DFW rates of 40%-60%. Since Spring 2001, there has been a decline in the DFW rate for College Algebra, which has been significantly restructured since the creation of the IML. Table 1 gives the exact figures. In addition to looking at students' grades, the College Algebra course co-coordinators wished to study the effects of the restructuring more carefully, and they have completed several research studies to do so. The purpose of this paper is to synthesize results from these completed studies, as well as to describe current and future research in the course. It is hoped that results from these studies will benefit others who teach, coordinate, or develop

introductory level college mathematics courses.

Table 1
College Algebra Grade Distributions Trends Spring 2001 - Fall 2006

Semester	%A	%B	%C	%D	%F	%W	%D/F/W
Spring 2001	8.1	14.1	16.2	18.9	18.9	NA	NA
Fall 2001	8.9	23.3	17.7	10.5	18.4	NA	NA
Spring 2002	8.4	18.9	18.9	15.2	12.8	25.0	53.0
Fall 2002	4.9	21.0	27.4	13.7	13.7	18.4	45.8
Spring 2003	12.1	22.1	29.5	11.7	11.7	12.8	36.2
Fall 2003	8.9	24.2	27.5	13.9	11.3	14.2	39.4
Spring 2004	7.9	23.4	23.7	16.5	13.3	15.1	45.0
Fall 2004	10.9	22.7	21.5	14.2	13.1	17.6	44.9
Spring 2005	8.2	20.1	28.6	11.6	13.5	17.9	43.1
Fall 2005	12.5	28.2	23.1	12	10.2	14	36.2
Spring 2006	6.9	22.6	23.7	15.1	15.1	16.6	46.9
Fall 2006	23.5	24.5	20.5	9	11.6	10.8	31.5

Note. Complete data is not available for Fall and Spring 2001.

Description of College Algebra

It should be noted that WVU offers two versions of on-campus College Algebra, and only the on-campus version that is part of the IML is included in this paper. Students are placed into College Algebra by successfully completing an algebra workshop, by passing a departmental placement test, or by having scored at least a 23 on the math ACT test. Many IML courses, including College Algebra, have 200-student sections. Thus, course coordinators have been creative in finding ways to help students. For example, since Spring 2003 the College Algebra course has included interactive computer laboratory assignments and online homework quizzes, which students complete on the WebCT course management system.

Furthermore, a Personal Response System (PRS) has been used in some sections since Fall 2004. A PRS is a combination of hardware and software that allows instructors to poll students with multiple choice questions during class. The students use handheld wireless transmitters to respond. Software immediately aggregates the answers and displays a frequency chart for each answer choice.

In Fall 2005 a lecture guide was introduced into the course. The guide gives students outlines of definitions and examples, which are discussed in class. Students fill in the definitions and work out the examples, either in class with the instructor, working in class on their own, or outside of class using their text. One goal of the guide is to help all students keep organized notes and identify key concepts in the course. It is hoped that the guide will be especially useful for students with learning disabilities.

A web-based College Algebra course has also been offered through WVU and research into this course has also been conducted. This course was designed in 1999 when the West Virginia Higher Education Policy Commission (HEPC) asked mathematicians and mathematics educators from higher education institutions to help design a mathematics course for high school students to take for early college credit. Primary goals of the HEPC are to increase the college attendance rate in West Virginia (West Virginia Higher Education Policy Committee, 2002) and to increase the ACT scores for West Virginia students (WVDE, 2001). The course entitled WvEB Algebra was created and the details of the preliminary outcomes of the project can be found in Pyzdrowski & Pyzdrowski (2001). The course is web-enhanced, has a university professor instructor of record, and has a high school mathematics teacher facilitator. Comparisons can be made between the on-campus College Algebra course and WvEB Algebra

because, since Fall 2003, the two courses have used the same syllabi and assessments. Before that time, due to lower enrollment, the WvEB course used paper and pencil tests that were developed and graded by the course coordinator.

Assessments and Grades

Since Fall 2004, a retired version of the ACT math test has been given in College Algebra and WvEB Algebra, as both a pretest and a posttest, to measure change in student achievement. Special research versions of the test were purchased from ACT, and this test was chosen for several reasons. For example, most college-bound West Virginia high school students take the ACT test, allowing comparisons to be made between the course and state performance results. Furthermore, there is currently an ACT Math Task force in West Virginia whose goal is to improve the college attendance rate and student performance on the ACT test. Therefore, results from the test are readily recognized when secondary and higher education teachers discuss student performance. Finally, it is intended to extend the research studies done in College Algebra to other courses, including College Trigonometry, so an instrument that can be used over time and which measures more than algebra skills is required. In the course, the same version of the test is used as a pretest and posttest, with approximately 3 months separating the tests. Each time students take the ACT test, they earn bonus points based on their score.

Final grades in the course are determined by the course co-coordinators based on several course components. There are 4 exams, a cumulative final, and 6 quizzes, all of which are completed on WebCT and scored electronically by the software. To encourage the students to learn from and correct their mistakes, the students have until the end of the semester to take three attempts on each quiz, and their highest score is counted. There are 8 written laboratory

assignments that are graded by course teaching assistants who meet weekly to ensure inter-grader reliability. Participation is worth 10% of the final grade. In many of the research studies discussed in this paper, comparisons among sections on ACT pre-to-posttest scores and on the course components have been conducted.

Findings from Completed College Algebra Research

Online Quizzing

Several research studies comparing WvEB Algebra and the on-campus course have been completed. In particular, WebCT online quizzes are used in both courses and their use has been investigated in Pyzdrowski & Pyzdrowski (2003), Pyzdrowski & Pyzdrowski (2002), and Butler & Zerr (2005). Some findings from these studies are of particular interest. For example, in WvEB Algebra final course evaluations for the 2002-2003 academic year, 82% of respondents indicated that the online quizzes helped them learn the course material, with half of these students reporting that the quizzes were the course component that most helped them learn. Furthermore, the correlation between the online quiz average and the score on the final exam was .83 for the on-campus sections during the Spring 2003 semester (Pyzdrowski & Pyzdrowski, 2003).

In the on-campus course, instructors are struggling to find ways to encourage students to use the quizzes to their advantage. For example, in the Fall 2004 semester, students were repeatedly reminded in class that they were required as stated on the course syllabus to work on Quizzes 1 and 2 to prepare for the first exam. The first exam was taken by 498 students and the average grade was a 63.1%. At 10:00 am on the morning of this exam, only 381 students had completed Quiz 1 at least once and only 252 students had completed at least one attempt on Quiz

2 (Butler & Zerr, 2005).

Personal Response System

In Spring 2004, WVU hosted a seminar on using PRS in science classrooms. Because faculty and administrators were looking to increase in-class student engagement, PRS use was implemented in some large sectioned mathematics courses, including College Algebra. During the Fall 2004 semester, a study was conducted to investigate differences in performance results between the 3 sections of College Algebra. One section used PRS and PowerPoint presentations; a second section used only the PowerPoint presentations, while the third section served as a control. More details on the use of the PRS in College Algebra can be found in Butler (2005) and complete details on this study can be found in Butler, Pyzdrowski, Walker, & Yoho (2006).

To compare the sections, quantitative and qualitative analyses were completed. Quantitative analyses included statistical comparisons between sections on the course components and on the ACT tests. It was found that the quizzes were the course component that had the greatest impact on the difference in the final grades between the sections. There was no significant difference between sections on the ACT tests, but all students gained an average of 1 scaled point. Furthermore, it is important to note that the mean scaled math ACT pretest score for students in all three sections was 19.93, which is close to the 2005 West Virginia average of 19.3 in 2005 (Average ACT Scores by State, 2005). However, this score is substantially below the math ACT score of 23 required to take the course. Furthermore, even the mean scaled posttest score of 22.17 is lower than the entrance requirements.

A survey on PRS was also given to students in the section which used PRS. For multiple-choice items on the survey, percentages were calculated for each answer option based

on the number of students who answered the question. For short answer items, two researchers independently read student responses to identify idea blocks and met to agree on these findings. While there were some difficulties using the new technology in the classroom, it was found that approximately 66% of students wanted to use PRS in future classes and overall written responses were positive. There was, however, a notable difference in the amount of class time students wanted to spend on PRS, which led to other research in the course.

Learning Styles

While conducting the PRS survey research in the course, it was noted that some students thought that PRS questions were not worth the class time and that there was a discrepancy in the amount of time that students thought should be spent on PRS questions. For this reason, the researchers wanted to investigate if different student learning styles could explain the range of student responses on the survey. Therefore it was decided to study learning styles in College Algebra in the Fall 2005 semester. One goal of the research was to see if particular learning styles correlate with student grades on course components, and if there are any learning styles which are not addressed by any of the current course components.

Students were given a learning styles inventory to complete outside of class on WebCT for a small amount of bonus points. The Center for Innovative Teaching Experiences (C.I.T.E.) Learning Styles Inventory by Babich, Burdine, Albright, and Randol (1976) consists of 45 questions, and was formulated at the Murdoch Teachers Center in Wichita, Kansas to help teachers determine the learning styles preferred by their students (WVDE, 2006). This inventory was chosen because it was readily available to the researchers through the West Virginia Department of Education and it has been used in other projects in the state. Three primary

attributes are evaluated through its use: Information Gathering, Work Conditions, and Expressiveness.

In addition, a survey was written by the researchers to assess which course components students preferred and to learn more about student learning styles. The surveys were not anonymous so that student responses could be tied to the results from the C.I.T.E. inventory. A preliminary analysis of this data has been completed and the details of this analysis are given in Pyzdrowski, Pyzdrowski, Butler, & Walker (in press, 2007). While there were some correlations of statistical significance, none of the learning styles were found to be highly correlated with any of the course components.

Although much of the survey data has not yet been analyzed, the results from the section where the instructor had the most experience using PRS and used the lecture guide to lead the course are interesting. Approximately 48 students returned surveys that were at least partially completed. In this section, 42 students picked the lecture guide as a helpful course component, and 31 students picked the lecture guide as the most helpful course component (over 63% of students responding). Of the students in this section, 25 picked PRS as a helpful course component, and 2 picked PRS as the most helpful course component. When asked if the lecture guide and PRS worked well with their learning style, 36 and 22 students, respectively, said yes. Only 3 students said that the lecture guide did not work well with their learning style, while 10 said this about PRS.

Current College Algebra Research

Learning Styles

Further analysis into the data from the Fall 2005 learning styles study is still being

conducted. For example, the researchers have grouped the surveys by the learning style reported for each student on the C.I.T.E. inventory. The researchers are reading each group of surveys individually, and then discussing the results as a group, to identify common idea blocks for each learning style.

WvEB Algebra Matched Pairs Study

Preliminary research into College Algebra and WvEB Algebra led the researchers to question why the WvEB Algebra students seemingly outperform the on-campus students so significantly, with higher course grade averages and lower DFW rates. To study this question, in the Fall 2004 semester 50 WvEB Algebra students were paired with on-campus students based on age, gender, high school background, and ACT scores. Comparisons between the students on the course components and the ACT tests are still ongoing. Preliminary results show that, when matched, on-campus students perform as well on pre to post-ACT measures as the WvEB students. In addition, the paired students are being tracked to the Spring 2005 semester. Data will be collected on which mathematics or statistics course, if any, these students took in Spring 2005. Furthermore, students who took WvEB Algebra may have taken WvEB Trigonometry. The Spring 2005 WvEB Trigonometry students also took a post-ACT test, so the results from the analysis of this additional data will be included.

PRS and Peer Collaboration

When reading research articles to prepare the College Algebra study on PRS, the authors encountered several articles on PRS and peer instruction. Several studies (Fagen, Crouch, & Mazur, 2002; Judson & Sawada, 2002) support the idea that PRS is most effective as a teaching tool when it is used in collaborative learning situations. For this reason, during the Fall 2006

semester in College Algebra a study was conducted to explore the differences between individual and collaborative PRS use. In Fall 2006, there were 3 sections of College Algebra. Section A served as a control by not including PRS and was taught by a senior instructor. Sections B and C were taught by a course co-coordinator, and both sections will use PRS. One of section B or C will be randomly chosen to use PRS collaboratively, while students in the other section will use PRS individually. The ACT continued to be used to measure change in student achievement and to allow for comparisons across sections. Finally, due to the results of the College Algebra Learning Styles study, the authors hope to continue this research in the future with a different learning style inventory (MIDAS, 2001).

Conclusions

Research in the College Algebra course supports many of the changes that have been made. In particular, the online quizzes with multiple attempts and interactive computer laboratories seem to be successful course components. More work is being done to incorporate PRS and the lecture guide into the course. For the Fall 2006 semester, for example, the lecture guide underwent extensive revisions based on student and instructor comments. In addition, it is hoped the research into learning styles will lead to new course components which will help all students succeed.

One of the biggest obstacles facing instructors in the course currently seems to be a lack of student preparedness, as evidenced by student performance on the ACT pretest. The researchers are also studying student performance on the ACT test in Precalculus, so this additional data may help guide future curriculum issues. For example, the Department of Mathematics at WVU is currently revising student placement policies. Furthermore,

administrators and educators at the state level are encouraging students to take more high school mathematics courses, especially in their final year of high school. Programs such as WvEB mathematics are also working toward this goal. In addition, it is hoped that information from College Algebra research can be shared with others who teach introductory level college mathematics courses. Finding instructional tools that benefit students with a specific learning style will be useful for course coordinators and developers at many levels.

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