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Students' Reactions to Reform Mathematics Pedagogy in a Postsecondary Remedial Mathematics Course

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Abstract: The students in this study were enrolled in a remedial mathematics course at a small 4-year university and were taught according to the reform pedagogical principles advocated by NCTM, AMATYC, and MAA. Since most of the students had not been previously exposed to these teaching methods, this study obtained students' reactions (n = 22) to the course through an anonymous, free-response (not multiple choice) survey at the end of the course. Surveys from students in two equivalent "traditional" lecture courses (n = 44) were also analyzed and served as a baseline by which to gauge students' responses from the reform group. The surveys asked for general likes and dislikes regarding the pedagogical practices that were employed in their respective courses. The findings from the surveys were that students in the reform course generally liked its key features (group work, student presentations, and graphing calculators), but roughly half of the class wished that the instructor spent more time doing many more example problems on the board as opposed to giving the class time to explore the mathematical principles underlying the example problems. Teachers who wish to use reform pedagogical practices need to be aware of student expectations as they plan their lessons.

Key Words: remedial mathematics, postsecondary mathematics, reform mathematics, student perceptions, problem solving, graphing calculators

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Introduction

Many students in the United States who have desired to earn a postsecondary degree have found themselves underprepared for postsecondary mathematics and were required to take remedial mathematics courses (Fike & Fike, 2007; Alliance for Excellent Education [AEE], 2011; Radford et al., 2012). Unfortunately, mathematics has become a gatekeeper for college success (Massachusetts Community College Executive Office, 2006; Fike & Fike, 2007; Epper & Baker, 2009) since attrition rates for postsecondary remedial mathematics courses have often been reported around 50% (Phoenix, 1990; Ellington, 2005; Attewell et al., 2006; Fike & Fike, 2007; Bahr, 2008; Virginia College Community System [VCCS], 2011). Even though traditional lecture techniques provide little benefit to students in remedial mathematics courses (Boylan & Saxon, 1999, Trenholm, 2006), many instructors continue to present their material to passive, uninvolved students (Fry, Ketteridge, & Marshall, 2003; White-Clark, DiCarlo, & Gilchriest, 2008). In order to improve student success in mathematics courses, several mathematics education organizations including The National Council of Teacher of Mathematics (NCTM), The American Mathematical Association of Two-Year Colleges (AMATYC), and the Mathematical Association of America (MAA) have recommended specific practices for mathematics teachers to use in their classrooms. For the purposes of this paper, the recommendations made by these organizations will be referred to as “reform” practices and include a shift toward active student learning through group work and exploration of mathematical phenomena before formal presentation of mathematical theorems.

A quasi-experimental study was conducted at a small four-year southeast university in Spring 2012 through Spring 2013 that examined the effectiveness of using reform-oriented techniques in a remedial mathematics course (Intermediate Algebra). In Spring 2012, one course was taught in a reform-oriented manner; in Fall 2012 and Spring 2013, one course was taught each semester in a traditional didactic manner. At the end of each of the three courses, an anonymous free-response survey was issued to the students to gauge their reactions to the type of instruction they received in their respective courses. This article will present the findings of those surveys with a focus on the feedback given by students in the reform-oriented course; the feedback from students in the traditional lecture courses will serve as a backdrop by which to interpret the feedback obtained from the reform-oriented course.

Review of Literature

Researchers in the reform mathematics movement emphasize the importance of balancing conceptual understanding with procedural fluency. This balance can be maintained when students actively participate in the learning process by exploring mathematical concepts in groups with the help of technology and by discussing and justifying their findings with their classmates. As a result, students may develop problem solving abilities and also understand the reasoning behind the mathematical principles they are taught. Because of the countercultural recommendations made by reformists (Smith & Star, 2007), researchers have examined the effectiveness of reform pedagogical practices at various grade levels and through a variety of metrics.

Research at the middle and secondary school level is worth considering since much of the content taught at this level is also included in postsecondary remedial mathematics courses (Bahr, 2008). Two relevant studies at the middle school level examined students' mathematical success in terms of statewide exams. Reys et al. (2003) found that middle school students who had used reform-based curricula for at least two years performed as well or better than matched comparison students on the Missouri Assessment Program mathematics exam. Thompson (2009) examined the instructional techniques used by middle school mathematics teachers and found that students whose teachers who used multiple reform techniques (including manipulatives and group-based projects) scored higher on the Iowa Test of Basic Skills than did students whose teachers used primarily traditional lecture techniques.

At the secondary level, researchers tended to examine students' abilities to apply their mathematical knowledge to problem solving (i.e. word problems). Hirschhorn (1993), Schoen, Hirsch, and Ziebarth (1998), and Thompson and Senk (2001) all found that students who used reform curricula did as well as or better than matched comparison students on problem-solving tests. The latter two studies also compared students' procedural abilities. Thompson and Senk (2001) found no significant differences in procedural ability between traditional and reform students. However, Schoen, Hirsch, and Ziebarth (1998) found that students in traditional courses outperformed students in reform courses, but students in reform courses eliminated these deficits by the end of their second year in the reform curricula.

At the postsecondary level, several studies examined the effects of using reform-based instructional techniques within the classroom, and their effectiveness was often measured in terms of procedural skills, application skills, pass rates in the current course, and pass rates in subsequent courses. In a mathematics course for elementary teachers, Lawson et al. (2002) found significantly high correlations between reform-oriented instruction and 1) students' post test scores, 2) achievement gains, and 3) number sense scores. Ellington (2005) found that students whose professors integrated cross-disciplinary topics, group work, and technology into their college algebra courses earned higher pass rates and higher scores in the algebra course than did students in the traditional course. However when Ellington (2005) tracked students' success in the subsequent Precalculus or Business Mathematics course (depending on their majors), the students in the reform course experienced lower pass rates in the subsequent Precalculus course and similar pass rates in the Business Mathematics course. Gordon (2006) found that students in Precalculus courses that utilized reform-oriented instruction demonstrated higher procedural skills and more positive attitudes towards mathematics than did students who received traditional instruction.

Similar studies have been done specifically in postsecondary remedial mathematics courses. Erickson and Shore (2003) found that by integrating a problem-oriented approach and cross-disciplinary content into their remedial algebra course, students in this course earned higher test scores and reported more positive attitudes than did students in the traditional course. Hooker (2011) found that students who engaged in collaborative learning experienced higher pass rates and higher persistence rates to the end of the course.

Although the aforementioned metrics are important when considering the merits of reform pedagogy, it is also important to consider students' reactions to the day-to-day instructional techniques that teachers use in reform-oriented classrooms (Smith & Star, 2007). One study worth noting is Roth-McDuffie, McGinnis, and Graeber's (2000) study in which they examined the students' reactions to reform-based instructional techniques that were used in a postsecondary introductory mathematics course. The researchers found that the students in the course exhibited one of two initial reactions to reform-based instruction. Five of the students in the course were mathematics education majors and knew before the course began that they would receive instruction in a reform-oriented manner (which they had never experienced before); these students reported throughout the course that they appreciated the way the course was taught. However, the remaining students (who only knew that they were enrolling in an experimental section of the course) initially were frustrated with the way the course was taught.

However, these students gradually came to appreciate by the end of the course the instructional techniques that they experienced.

As can be seen in the previous studies, students who are taught mathematics through reform-oriented curricula and techniques often improve their mathematical success in terms of pass rates and problem solving abilities. These successes have been seen at the middle, secondary, and postsecondary levels of education. However, few studies have examined the effects of reform pedagogy in remedial mathematics courses at the postsecondary level, particularly in terms of students' reactions to those techniques. The follow sections describe how this study adds to the literature by exploring students' perspectives of specific reform-oriented techniques in the context of postsecondary remedial mathematics courses.

Methodology

Because students' perspectives are important to consider when evaluating the effectiveness of a particular form of instruction (Ernest, 1997), this study attempted to evaluate the effectiveness of reform pedagogical practices in postsecondary remedial mathematics courses by considering the perspectives of students who received such instruction. The perspectives of these students were interpreted in light of the reactions expressed by other students who were enrolled in corresponding traditional lecture courses. Anonymous end-of-course surveys served as the basis for analysis in determining students' views of reform-oriented instruction. These surveys were coded according a strategy advocated by Miles and Huberman (1994) in which a "start list" of predefined codes was used that was based on the survey questions and the students' possible responses to these questions. Once the surveys had been administered, a representational approach which uses key words to identify core concepts was used in order to fairly represent students' comments (Sapsford, 1999). As themes emerged from the data, additional codes were created; and once all of the students' statements could be readily classified according to the existing set of codes, the coding process was terminated (Miles & Huberman, 1994).

Students in this study were enrolled in an Intermediate Algebra course which included topics such as factoring techniques, rational expressions and equations, operations with and graphing of functions, simplifying radical expressions and solving rational equations, and solving and graphing quadratic equations. Qualitative data was gathered from students in a total of three classes: a reform-oriented class in Spring 2012 (n = 22) and a two traditional lecture classes in Fall 2012 (n = 23) and Spring 2013 (n = 21). Students were not randomly assigned to their courses; however, students chose their courses based on the convenience of their class schedules, and they did not know until the first day of class which treatment they would receive. The lead investigator in this study was also the instructor for all three of these courses.

The Reform Course

Three prominent components of reform mathematics include the use of graphing calculators or other forms of technology, students working together in groups to explore and solve problems, and students regularly engaging in informal presentations in which they presented their findings to their group mates and the class as a whole (NCTM, 2000; Boylan, Bonham, & Tafari, 2005; AMATYC, 2006; Thompson, 2009; CUPM, 2011). These three components worked together in the reform classroom to create a learning community in which students were given a chance to explore and potentially deduce mathematical theorems before those theorems were formally presented. The incorporation of these three components into the reform course is presented in the paragraphs below.

Throughout the reform course, students were encouraged to use both algebraic and non-algebraic approaches to explore mathematical phenomena. Graphing calculators were instrumental in this objective because they allowed students to quickly construct tables and graphs to explore problems and to test the reasonableness of their solutions. Students were supplied with graphing calculators during class and shown how to use them. Although students were responsible for obtaining graphing calculators outside the classroom, they were encouraged to use the graphing calculators at a nearby tutoring facility, and they were also shown how to access online graphing calculators.

During group work, students worked together at tables to solve the problems or questions that the instructor presented. If a student had a question, he was to ask his group mates first. If no one at his group could answer his question, then the student could ask the instructor. If the instructor believed that the student could answer the question on his own, the instructor would respond with a leading question that would help the student answer his own question. However, the instructor sometimes simply answered the question if it would take too much class time for the student to answer the question on his own. The instructor answering a student's mathematical question without pushing the student to answer his own question was done rarely and only as a last resort.

After students explored the problems presented to them and discussed their answers with their group mates, they were asked to present their work to the rest of the class. During these presentations, the other students were expected to assess the accuracy of the presented information and follow up with respectful constructive criticism in an intellectually safe environment. Student presentations were intended to improve students' understanding by reinforcing what the students had learned, by helping other students understand the mathematical concept, and by training students to justify to their classmates the reasoning behind their solutions. Using an overhead document camera significantly facilitated students' presentations by allowing them to simply show their work without recreating their work at the board.

The Traditional Course

In the traditional lecture course, the instructor spent approximately 95% of class time explaining to students the mathematical concepts within the course, with the remaining time spent by students asking questions. Each meeting the instructor introduced mathematical concepts and explained how to solve related problems in a simple, step-by-step fashion. During class, students sat in individual desks and did not work in groups. Since algebraic approaches were typically the most efficient and straightforward means to solve problems, technology (such as the table and graphing functions of graphing calculators) were not used to introduce or reinforce mathematical concepts. When students asked questions about the material, the instructor answered their questions fully and to their satisfaction. However, the instructor did not probe students' understanding with the objective of helping them to figure out the answer to their own questions.

Instruments

On the day of the final exam, students in both the reform group and the traditional group were given surveys containing the following questions:

1) How does this math class compare to other math classes that you have had? Explain.

2) What are some things you liked about the course?

3) What are some things you did not like about the course?

4) Other comments.

Both groups were asked the first question in order to support the researchers' claim that the pedagogical techniques used in the reform course were significantly different from those used in the traditional lecture group. Questions 2-4 presented both groups of students the opportunity to express their opinions about favorable and unfavorable aspects of their respective courses. However, because this study wished to learn more about students' reactions to specific features of reform pedagogy, the survey in the reform course contained three additional questions:

5) To what extent did you like working with your classmates during class? Explain.

6) Did you find the graphing calculator useful? If yes, please explain how/when it was useful.

7) To what extent did you benefit from presenting your work to the class (or watching your classmates present their work to the class)? Explain.

Results

In addition to the results from the reform course, the results from the traditional courses will be presented when doing so may provide a backdrop by which to interpret the results gathered from students in the reform course. As was expected, the comments made by students in the traditional group were largely different from the comments made by students in the reform group with respect to the question, "How does this math class compare to other math classes that you have had? Explain." Seventeen students (38.6%) in the traditional group made positive comments regarding the instructor's ability to explain the material, and only one student (2.3%) made any negative comments regarding the instructor's explanations. A typical comment was, "This [course] is very easy because our instructor simplifies the problems, so everyone can learn it and grasp on to the concept." Another student approvingly stated that the instructor "taught us in detail the steps of a problem."

In contrast, eight students (36.3%) in the reform group (and no students in the traditional group) stated that group work and opportunities to learn the material themselves stood out as distinguishing characteristics of their course, and no students in the reform group commented that the *instructor's* ability to break down problems into steps was a distinguishing attribute of their course. In fact, several students expressed strong displeasure at the instructor's not immediately answering their questions and instead encouraging them to explore in their groups mathematical concepts before the concepts were formally presented. One student stated, "I don't deal well with 'figure it out yourself' methods. I need to be told how to do something or else I will never get it." However, eight students (36.4%) in the reform group explicitly stated that they did "get it" through comments such as "We actually learned WHY things in math are the way they are. And we were asked why does a graph do this and how does the equation give certain values. Other classes told us 'this is the answer and that's it'" (quotes added). Thus, students in the reform group clearly recognized the change in classroom practices from their previous traditionally taught mathematics courses.

With respect to student presentations, fifteen students (68.2%) in the reform group expressed positive comments by noting that presentations 1) pushed them to improve the quality of their mathematical work, 2) improved their understanding of mathematical concepts by observing approaches made by their classmates, and/or 3) increased their confidence in their speaking and mathematical abilities. However, five students (22.7%) expressed either negative or mixed feelings about student presentations; these students stated that presentations could at times be confusing or that class time could have been spent doing more examples.

Similar to comments regarding student presentations, fifteen students (68.2%) in the reform group also expressed generally favorable views of working together in groups. These students stated that they benefited from the support structure inherent within their groups because they were able to 1) help each other understand concepts during class and 2) share alternative ways to view a particular concept. One student stated that working with classmates was helpful because "it brought up different views and opinions of problems that were beneficial to knowing problems inside and out." Four students (18.2%) expressed mixed or negative comments regarding groups because they preferred not to share their work or because they desired the instructor himself to explain to them mathematical material.

In the reform class, students overwhelmingly supported the use of graphing calculators as a part of the course. All twenty-two students (100%) in the reform course expressed positive views of graphing calculators. Students stated that graphing calculators helped them graph functions, solve problems, and verify solutions to their answers. Additionally, students stated that they were able to create graphs and tables as alternative means to algebraic approaches to solve problems. Students made no negative comments regarding the use of graphing calculators.

Despite students' relatively high approvals of key reform techniques through the incorporation of student presentations, group work, and graphing calculators, students' explicit comments regarding the day-to-day teaching methods were comparatively more negative. Although five students (22.7%) explicitly stated that they enjoyed the teaching method used in the class, with one student even stating that "the professor didn't stand in front of class and lecture boringly every day" and another student stating "I didn't hate waking up in the morning for math for a change after the teachers in high school," several students expressed concerns about the way the course was taught. For example, four students (18.2%) stated that they wanted to see more examples or a wider variety of examples worked during class. One student stated, "Too much time trying to figure things out on my own. I like a teacher that teaches the whole time. Example…example…example." Three other students (13.6%) stated that they simply would have preferred learning in a traditional manner. One student succinctly stated, “[I disliked] pretty much everything.”

In contrast, nineteen students (43.2%) in the traditional group spoke very highly about the instructor’s lectures and/or his ability to explain concepts to students, and only one student (2.3%) criticized the instructor’s teaching style. When students were asked if they had any negative comments to express regarding their course, twenty-one students (47.7%) in the traditional group versus six students (27.3%) in the reform group explicitly stated that they did not have any negative comments to provide.

Discussion

Several limitations in this study inhibited the generalizability of its findings. First, the sample size was relatively small. A larger sample size would have increased the confidence in the study’s results. Second, this study was performed in a smaller southeast university with a group of students who had never before experienced a reform-oriented mathematics course. Students with different academic backgrounds may have responded differently to the teaching strategies employed in this study.

This study attempted to understand students’ reactions to three key reform techniques: working together in groups, presenting (or listening to students present) to the class the findings of their group, and using graphing calculators to aid in their problem solving and exploration. The researchers found that most of the students in the reform group stated that they benefited from group work and student presentations. Interestingly, all of the students in the reform group stated that they benefited from using graphing calculators. However, several additional themes emerged from the data.

First, the default perspective for students across all three courses was that “good” teachers break down the material for their students and show them how to solve many examples of problems using detailed, step-by-step instructions. Students in the traditional courses spoke highly of the instructor’s ability to explain the material, and several students in the reform course were frustrated throughout the semester by the lack of direct explanations by the instructor. Thus, the results of this study differed somewhat from those of Roth-McDuffie, McGinnis, and Graeber (2000) in that the students in their study were able to be won over by reform pedagogy by the end of their course.

Second, and related to the first point, several students in the reform group believed that the instructor should have solved more problems during class. Due to the limited amount of class time, a logistical trade-off naturally exists between covering fewer problems in greater depth (through teacher questioning, group explorations and discussions, and student presentations) and covering more problems in less depth (through the teacher presenting and then solving problems during class). Thus, students expressed a common misconception that watching more problems solved equates to increased understanding.

Conclusion

Instructors who would like to incorporate more reform-oriented instruction into their remedial mathematics courses may benefit from the findings of this study since their students may react similarly to such instruction. Knowing what students tend to define as “good” teaching can enable instructors to alleviate some initial student frustration by discussing with their students the merits of reform techniques.

Students can benefit substantially from college success, but remedial mathematics courses are preventing many of them from achieving college success. The high percentage of failure rates in remedial mathematics courses (Hern, 2012) indicate that these courses need to be improved. The pedagogical practices advocated by the reform mathematics movement may be a solution to improving students' understanding of postsecondary remedial mathematics. One student's statement embodies the goals of any mathematics teacher, "[The class] was different, but I learned MUCH more. I feel like I learned 'math,' not just [material specific to this course]. I feel like I have a lot more tools now to use in my next math course." By understanding what students think about reform pedagogy, instructors of these courses can better diffuse the initial frustration that comes with a new way of learning and equip students with the mathematics that they need.

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