Formative Assessment: Reducing Math Phobia and Related Test Anxiety in a Geology Class for Non-Science Majors

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Abstract: Math and test anxiety are common in science classes for non-science majors. Formative assessment was used to prepare such students for exams. This included weekly quizzes that were challenging, graded harshly, and completely correctable (corrected grade completely replaced original grade). By the midterm, 100% of the students mastered rate calculations, and when retested at the final, 80% of the students retained the ability to solve the rate calculations. Students also reported feeling less math phobic.

Math and Test Phobia

Students in science classes for non-science majors often excel in other academic areas but believe they are not able to do math or to do well on science tests, and this disabling math and test anxiety prevents students from learning. This recursive cycle serves to confirm what the students already believe about themselves: they are poor at math and science. Math and test anxiety can be characterized, regardless of the original source, as an inability or unwillingness to engage in risk-taking behavior (Williams, 1988). The main causes stem from poor preparation and negative feedback, and in some cases, teachers run the risk of spreading the "communicable disease of math anxiety" that they themselves are carriers of (Williams, 1988). An estimated two thirds (Jackson and Leffingwell, 1999) to 93% (Burns, 1998) of Americans have negative associations with math. Test anxiety may result from poor study skills, the setting of unrealistic goals, hostile test environments, and impromptu testing, such as pop-quizzes (Sogunro, 1998).

How can math and test anxiety be reduced?

Previous research has suggested both pedagogical and therapeutic techniques for reducing math and test anxiety. Pedagogical techniques include creating positive experiences to replace the negative ones that fostered the anxiety, and using informal and ongoing assessment (Steele and Arth, 1998) with "regular and constructive feedback" (Sogunro, 1998). Therapeutic techniques include confronting negative experiences, journaling, various types of counseling, and offering personal stories of success to offer students hope. We are cautioned that "changing negative beliefs is a slow process" (Dodd, 1992).

Formative Assessment

Formative assessment provides a space for students to practice intellectual risk-taking behavior. When feedback is provided, followed by time to revise thinking, learning is promoted because the assessment is not seen only as a measure of success/failure (Black and Wiliam, 1998). Because formative assessment helps to make the student thinking more visible, the teacher may respond to specific needs or discover that a topic may need to be retaught.

Methods and Interventions

Participants were University of Texas students with regular attendance (fewer than 5 absences) enrolled in spring 2003 sections of Earth, Wind, and Fire, a geology class for non-science majors (N=50). 66% of the students were female, though gender turned out not to be a significant predictor of math and test anxiety. Students are expected to master calculations of rate, area, and unit conversion as tools for understanding geology, but experience with this course in previous years suggested that rather than serving to elucidate, these math problems act as blocks. Participants were surveyed about math and test anxiety and the instructor discussed the purpose of formative assessment and math and test anxiety. Quizzes were given weekly and graded harshly without indication of where errors had been made. New topics were added weekly and troublesome topics were repeated. The approximate average quiz grade each week ranged from 40-60%. Students were then encouraged to correct the quizzes; the new grade completely replaced the original grade. Students reported using various methods to correct the quizzes: Instructor office hours, notes and book, groups, and a few even copied/cheated (However, this was not entirely a negative effect because to get full credit, work had to be shown. Therefore, a student who is copying an answer is effectively taking notes). Grades on quizzes

and number of quizzes corrected by students were tested for correlations with the midterm and final exam grades.

Results

All participants mastered the math by the midterm exam, and most (80%) were still able to do the math on the final exam. Mastery of math in sections not using this method of formative assessment ranged from 40% to 70% on the midterm exam and 30% to 60% on the final exam. There is a significant positive correlation between number of quizzes a student corrected and midterm and final exam grade *($r = 0.346, n=50, p<0.01$)*, and there is also a significant positive correlation between average quiz grade and midterm and final exam grade *($r = 0.41, n=50, p<0.01$).* There were no significant gender differences.

Additionally, students reported feeling less nervous about the exam, compared to how they felt about other exams science and math exams. Comments from students' course evaluations suggest that they understood the reasoning behind the quizzes: "I really like the policy of correcting quizzes and having them often." "She teaches exactly how school should be taught, less emphasis on grades (because she allowed corrections) and more on learning which is what class is all about anyway." Prior to the midterm, many students left questions completely unanswered when they were unsure, but after their success on the midterm, most of the students made some sort of attempt to answer all questions, even if they were unsure. This suggests that the quizzes opened up a space for students to engage in intellectual risk-taking behavior.

Conclusions and Implications

Students with math and test anxiety can be given successful experiences to replace past failures through formative assessment. A supportive environment enables students to understand the purpose of the quizzes: to instruct, not just to evaluate. By frankly discussing math anxiety, a safe environment was created for students to engage in intellectual risk-taking behavior. The quizzes helped to interrupt damaging practices common among math anxious students by making them aware that they are not the only ones who struggle and by showing them that they *can* do the math. This method also relieves test anxiety because students get opportunities to learn the instructors' assessment style, to receive feedback, and to assess what they still need to study.

References

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