

Formative Assessment: Reducing math phobia and related test anxiety in a geology class for non-science majors

Vanessa Svihla, Department of Curriculum and Instruction, The University of Texas at Austin

Abstract

Math and test anxiety are prevalent in society, and tend to be overrepresented in science classes for non-science majors. Students in these classes often excel in other areas but believe they are not able to do math or to do well on science tests. After teaching labs as a TA for Earth, Wind, and Fire, a geology class for non-science majors, I became aware of how disabling math and test anxiety were for many of these students. The next time I taught labs for this course, I used formative assessment to help reduce math and test anxiety. Although many authors have stressed the importance of alternative methods of evaluation, I knew, realistically, that these students would need to be able to take traditional exams. To provide students with the training to succeed in such an environment, I gave weekly quizzes that were very challenging, graded harshly, and completely correctable. Students were encouraged to correct their quizzes, and the corrected grade completely replaced the original grade. By the mid term, 100% of the students had mastered rate calculations, and when retested at the final, 80% of the students retained the ability to solve the rate calculations. Students commented feeling less nervous about the midterm exam because they knew they could answer the math questions.

Math and Test Anxiety

- Characterized by feelings of dread and paralysis, inability to complete answers
- Main causes: poor preparation and negative feedback
- Generally math and test anxiety are linked
- Two thirds (Jackson and Leffingwell, 1999) to 93% (Burns, 1998) of Americans have negative associations with math
- an "I can't" syndrome" (Williams, 1988)
- "Emotional and a cognitive dread of mathematics" (Williams, 1988)
- Math anxiety is isolating (Dodd, 1992)
- 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).
- Attributed to the actions, whether overt or covert, of teachers (Williams, 1988), and of parents.
- Teachers run the risk of spreading the "communicable disease of math anxiety" that they themselves are carriers of (Williams, 1988).
- "Habitual, irrelevant, negative thoughts...during a testing situation" (Mealey and Host, 1992) causing distraction
- Women report higher rates of math anxiety (Levine, 1995) even in cases when they outperform men.

How can math and test anxiety be reduced?

- Pedagogical:
- Creating positive experiences to replace negative ones which fostered the anxiety
 - informal and ongoing assessment (Steele and Arth, 1998)
 - "regular and constructive feedback" (Sogunro, 1998)
 - Give easier problems to students with known weaknesses, guaranteeing their success (Williams, 1988).
- Therapeutic:
- Confronting negative experiences
 - Bibliotherapy, journaling, and group work, math autobiographies
 - Teacher as counselor (Furner and Duffy, 2002), (Eisenberg, 1992)
 - Personal stories of success may offer students hope
 - "Changing negative beliefs is a slow process" (Dodd, 92)
 - Need teachers who are patient and encouraging" (Dodd, 1992)
 - Many cases may also require counseling

Formative Assessment

Feedback provided, followed by time to revise thinking
Promote learning, not as a measure of success/failure
Improves learning considerably (Black and Wiliam, 1998)
Makes student thinking visible to the teacher and the students
Collaborative and constructive
Can be formal or informal
Considers preconceptions, existing knowledge
Focus on path from informal to formal thinking
Monitor progress to teach metacognition (such as self-assessment)
(fostered by questions at the end of a calculation that ask students to compare their answer to what they expected from their understanding of processes (such as, "Thinking about rates of plate movements, does this answer make sense?")
Focus on understanding, though procedures can be learned this way also
Encourages Academic risk-taking (NRC, 2000; Black and Wiliam, 1998)
Classroom Response Systems (CRS)
Prompt feedback

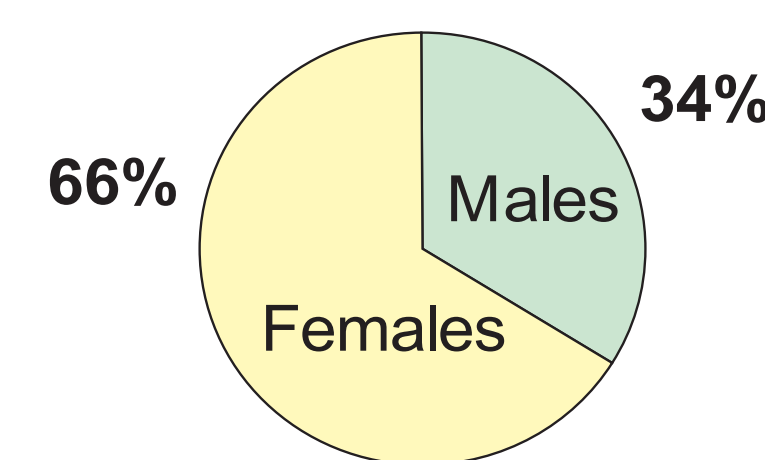
Methods and Interventions

Participants:

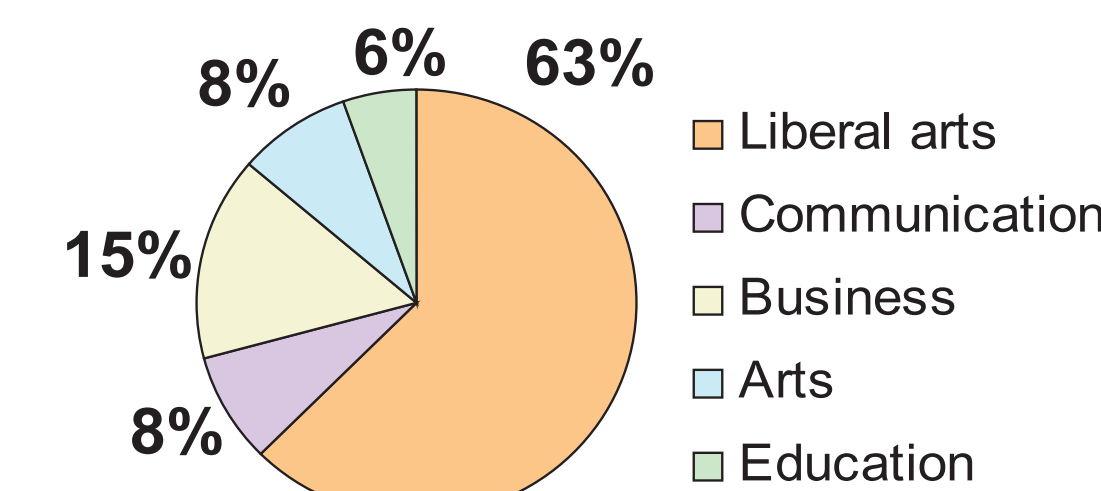
University of Texas students with regular attendance (fewer than 5 absences) enrolled in my spring 2003 sections of Earth, Wind, and Fire, a geology class for non-science majors (N=50).

Surveyed about math/test anxiety and reason for taking course

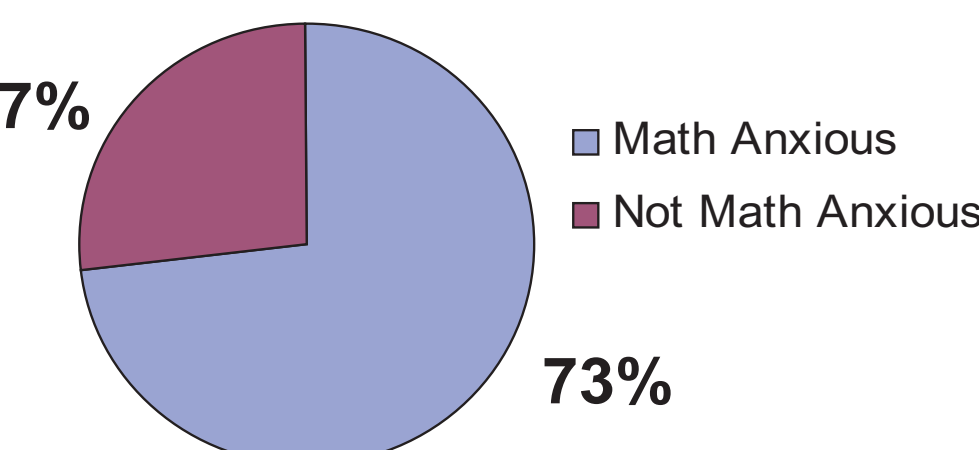
Male Female Ratio



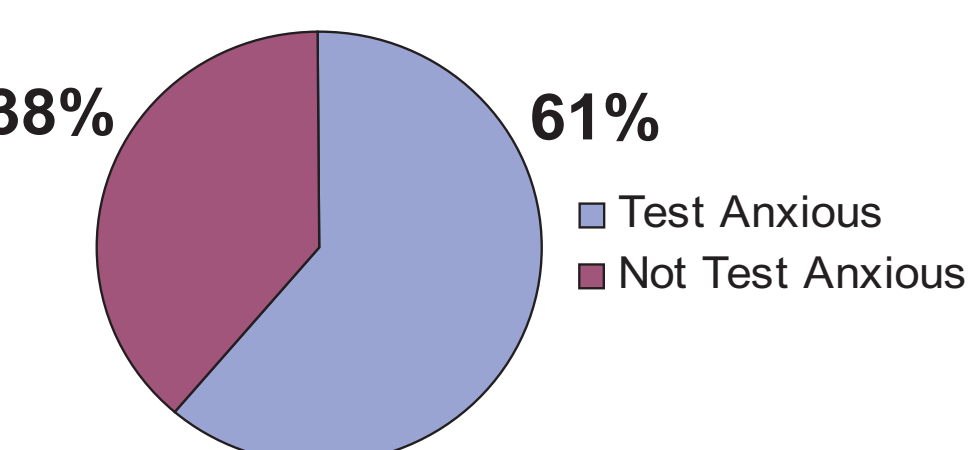
Departmental Majors



Math Anxiety



Test Anxiety



Methods:

Quizzes given weekly, graded harshly, with new topics added

Approximate average grade: 40-60%

Explained the purpose of formative assessment

Students could correct the quizzes; New grade completely replaced original grade

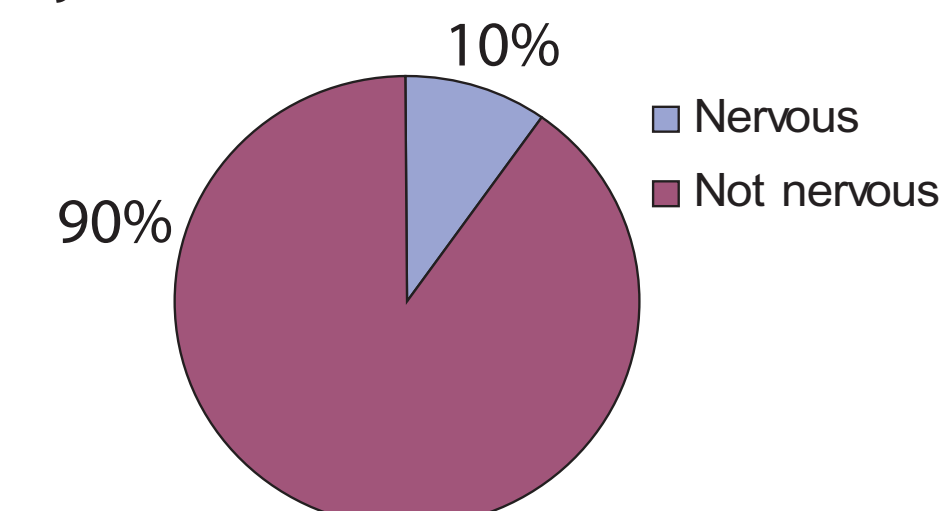
Tactics for correcting quizzes:

Office hours, notes and book, groups, and a few even copied/cheated (However, this was not entirely a negative effect because the correct answer to any math question could not just be a number. To get full credit, work had to be shown. Even a student who is cheating by copying an answer from someone is effectively taking notes)
Grades on quizzes and number of quizzes were tested for correlations with midterm and final exam grades

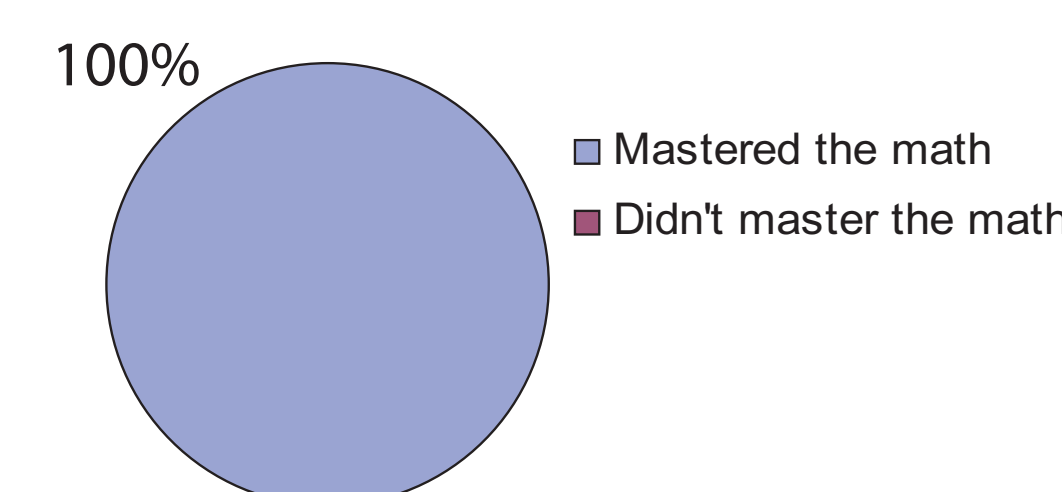
Results

- All students who had attended class 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 taught by other TAs who were not using compassionate quizzes ranged from 40% to 70%
- Students reported feeling less nervous about the exam, compared to how they felt about other exams

Ten most anxious students just before the midterm exam



Midterm Exam



Comments from students on course evaluations:

"I really like the policy of correcting quizzes and having them often"

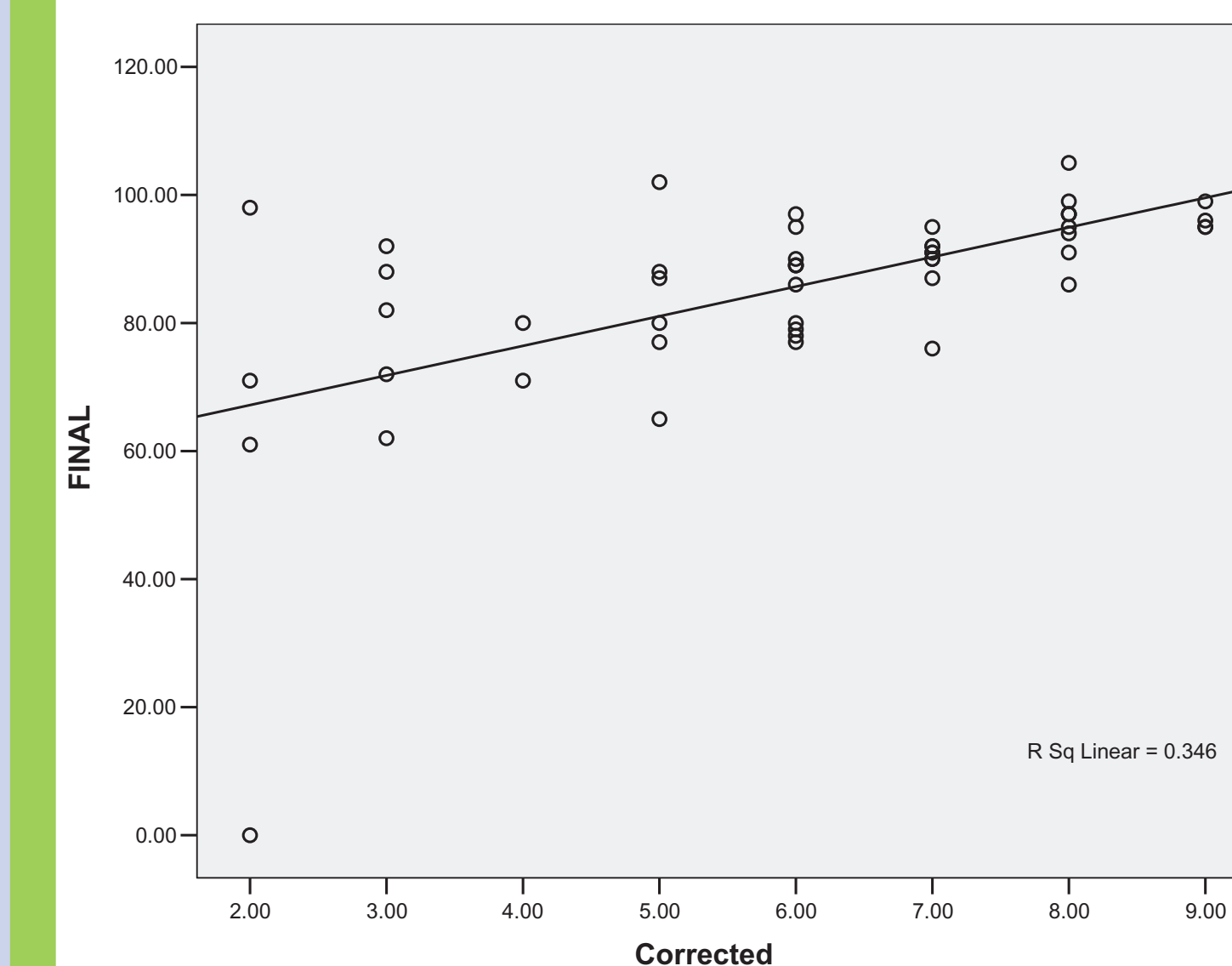
"She teaches exactly how school should be taught, less emphasis on grades (because she allowed corrections) and more on learning which is what class is all about anyway."

Correlation

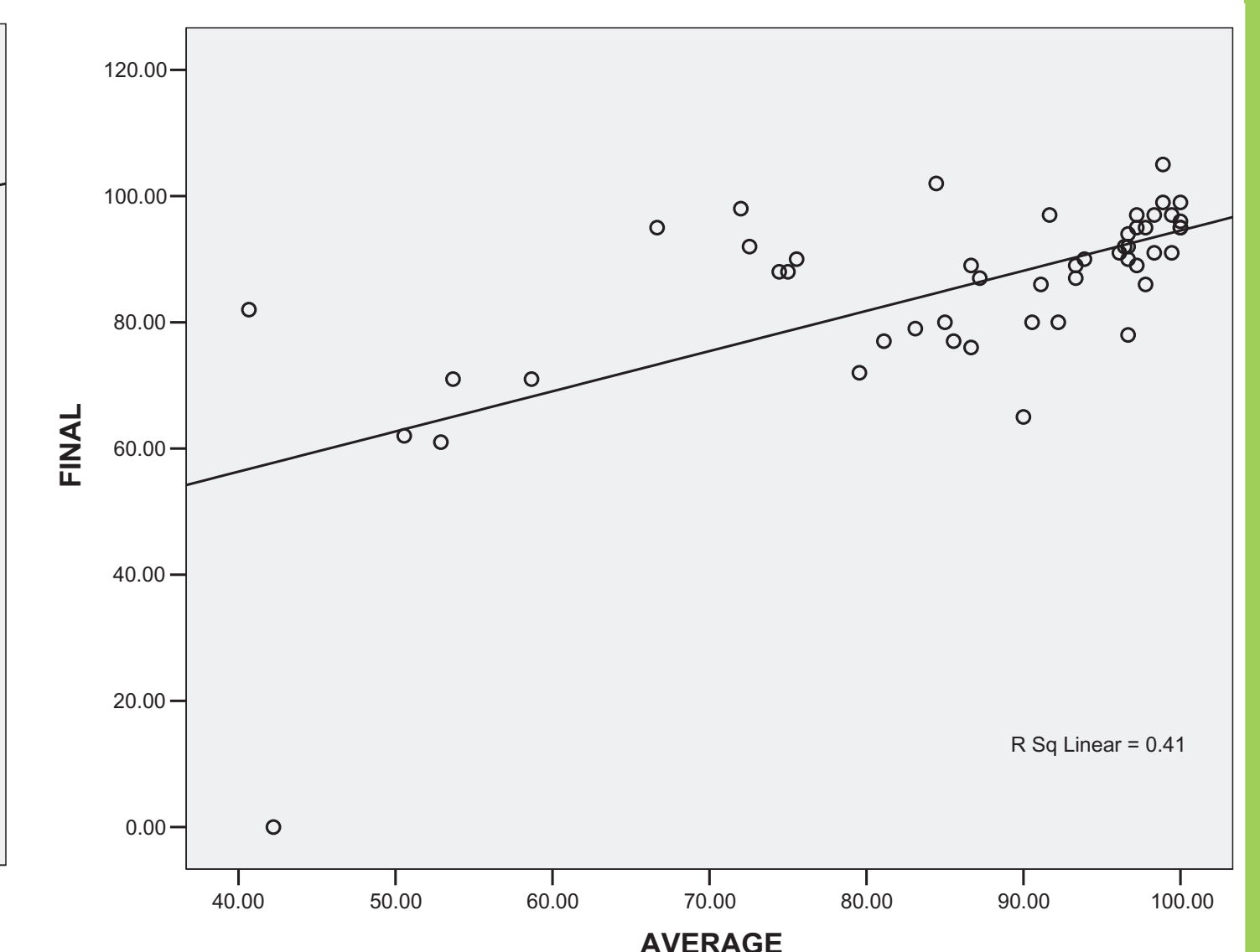
Positive correlation between number of quizzes corrected and midterm and final exam grade (significant at .01 level)

Positive correlation between quiz grade and midterm and final exam grade (significant at .01 level)

Results



Correlation between Final Exam Grade and Number of Quizzes Corrected



Correlation between Final Exam Grade and Average Quiz Grade

Conclusions

Formative Assessment is an effective for

- Teaching
- Knowing what your students know
- Letting your students know what you expect them to know
- Getting students comfortable with taking tests

Implications and Suggestions

Students with math anxiety and test anxiety can be retrained by using Formative Assessment. A supportive environment is vital so that the students understand the purpose of the quizzes: to instruct, not just to evaluate. By frankly discussing math anxiety, I was able to create a safe environment and offer hope to those confronting it. By using formative assessment, I interrupted 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, to take risks in a safe environment, and to assess before major exams what they know and what they still need to study.

Classroom Response Systems

This technique could be employed in a large class

Feedback would be immediate

Would allow the instructor to know what was not understood by the class and to act on that knowledge

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