Dr. Fred Savitz, Professor of Education, Neumann College
Dr. Ryan Savitz, Assistant Professor of Mathematics, Neumann College
National Council of Teachers of Mathematics Annual Meeting, Atlanta Georgia, March 21-24, 2007

Representing the Future: M3 =Mathematics, Multiple Intelligence, and Multicultural Education

Abstract

The first year college experience is anxiety producing, and for college students who represent traditionally underserved populations, particularly ethnic and linguistic minorities, the anxiety can be even more pronounced. Add to the mix a requirement for students to complete at least one course in mathematics during the first semester and the conditions are set for potential academic disaster. To mitigate against this prospect a father son team, the father a professor of education and the son a professor of mathematics, pools their discipline expertise in order to create opportunities for successful learning experiences in college mathematics. The team applies pedagogical theory to the content of college algebra with a focus on providing low stress, high achievement experiences for students from any population, but especially for those who are historically underrepresented among the ranks of college students. The team develops activities and assessments in mathematics, grounded on a foundation of classical and contemporary best practice. The desired outcome of the team's effort is to diminish anxiety and to elevate performance in first year college mathematics.

Introduction

What kinds of experiences provide opportunities for constructing knowledge about a brand new concept? How can mathematics teachers ensure that these experiences minimize the anxiety level of their students? For college students who represent traditionally underserved populations, particularly ethnic and linguistic minorities, the anxiety can be even more pronounced (Sagona 2003). How can prospective mathematics teachers tap into the diverse intelligences of their students in order to exploit the construction of that knowledge (Ashcraft and Kirk 2001)? How can the effectiveness of alternative approaches to conventional mathematics instruction be assessed? These questions will be addressed in this paper (Savitz & Savitz 2004).

Theoretical Rationale

Our primary duty as full time faculty members at Neumann College is to teach introductory level mathematics and statistics courses, as well as a variety of education classes. The content of these mathematics courses consists of many of the classic theories and concepts in elementary mathematics familiar to mathematicians. The students in these classes are typically first year college students, who come from a diverse array of backgrounds. Many of the students represent traditionally underserved populations, particularly ethnic and linguistic minorities. Students who are new to the discipline, however, find much of the course content to be alien to their own repositories of prior knowledge. Paramount among our goals, therefore, is to assist the first-year students who take this course to establish vivid schemes containing key elements of mathematics. To reach this goal we rely on the constructivist notions of John Dewey (1938) and Jean Piaget (1950). These notions enable us as instructors and our students as (anxious) learners to participate in experiences that facilitate the construction of new forms of knowledge and the acquisition of new arrays of skill. They inform our teaching by reminding us how to provide appropriate learning experiences for our students. We also wish to reduce the level of math anxiety of our students, as difficulty in mathematics classes plays a key role in the retention of first year students.

Our efforts at reducing math anxiety are grounded in the theoretical notion that learners achieve most and achieve best when they apply the kinds of intellectual processes with which they are most comfortable. Hence, we design our classes and structure their activities around a multitude of ways for students to demonstrate conceptual mastery and skill development. Essentially, this means incorporating the multiple intelligence theory advanced by Howard Gardner and utilizing the assessment tools delineated by Benjamin Bloom. Our experiences over the last six semesters have shown us that this individualized approach to learning (fostered by engaging students' preferred intelligences and sometimes referred to as differentiated instruction) and the standardized approach to assessment (delineated by Bloom in his three domains of learning) result in retention rates surpassing rates in sections of mathematics classes where more conventional approaches are taken to instruction and assessment. Our findings suggest that the retention rate averages ninety percent, in contrast to the sixty to seventy percent rate of retention observed in our classes' counterparts. Furthermore, of the approximately ninety percent of students who complete the course, over 90% do so with a grade of "C" or better. This outcome stands in stark contrast to the more traditional classroom rate of achievement, where it is not uncommon to have pass rates as low as 58% (http://faculty.valencia.cc.fl.us/srobinson/papers/remediat.htm).

We get help from Dewey by remembering how to engage our students in experiential learning activities. By structuring classroom episodes within the context of Dewey's mind/body paradigm (Experience and Education, 1938), ways of knowing and doing are developed through auditory, kinesthetic, and visual modalities. We use this mind/body paradigm in order to enable students to build new schemes associated with concepts about mathematics, schemes that students need to establish in order to become successful in any quantitative field.

Consequently, students create an operating system in their minds, which they can refer to as "the teaching/learning process." This is a scheme, which, in Piagetian terms, will allow our students to accommodate and assimilate previously unfamiliar knowledge and skills about mathematics. Our students literally construct new knowledge about classroom performance by experiencing the classic theories (Hyerle 1996) advanced by Dewey, Piaget, and Bloom. Classroom experiences engage students' auditory, kinesthetic, and visual capabilities as they build this new scheme called the teaching/learning process (Brooks and Brooks 1993).

This constructivist methodology in our classroom lets students appreciate a virtual encounter between Howard Gardner and Benjamin Bloom. The integration of Bloom's Taxonomy (Bloom, Englehart, Furst, Hill, and Krathwohl 1956) into our classroom methodology is a key to the success of our students.

The aforementioned constructivist methodology is especially relevant in a culturally and linguistically diverse classroom. Each type of learner, regardless of cultural background or linguistic orientation, is presented the curriculum in multiple ways, and has multiple opportunities to demonstrate the skills they have acquired. The atmosphere we create fosters the opportunity to deal with unfamiliar content on several levels (Banks and Banks 1989). These levels can be as simple as a single classroom reference related to a cultural or linguistic phenomenon, or as complex as a curriculum designed to reflect the multitude of cultural backgrounds and linguistic orientations. All of these aspects of curriculum, instruction, and assessment contribute to our ability to effectively teach to a diverse student population. And so we acquaint our students with the daunting role of being a college freshman with a tune (apologies to John Lennon and Paul McCartney) that laments having missed a class or bombed a test when, in fact, it was all but a dream, a high achiever's nightmare:

I JUST HAD A CLASS

I just had a class but I forget the time or place where it just met
It was the class for me but I forgot to go and see that class
Na na na na na na.

Had it been another day
I might have even had an A
But as it is I missed that class
And now I think I'll never pass that class.
Na na na na na na.

(chorus)
Failing, yes I am failing
And now I'm wailing
About that class.
Failing, yes I am failing
And now I'm wailing
About that class.

I just took a test
In which I thought I did my best
But when I got it back I took a look
And saw that I had got the hook.
On it, na na na na na na.

(chorus)

I just had a dream
And I awoke with such a scream
Because I know I never missed that class
And now I think I'll surely pass that class.

Na na na na na na.

(chorus)
Dreaming, yes I am dreaming
And now I'm screaming
About an A.
Dreaming, yes I am dreaming
And now I'm screaming
About an A.

In no time "I Just Had a Class" is adopted as "The College Algebra Theme Song." Shortly thereafter, it becomes the mantra for achieving success as a first year college student.

Theory to Practice

How to fit the domains of learning from Bloom's Taxonomy into a new scheme, then, demands the application of genuine, authentic experiences. We model contemporary practices in our lessons, and we engage students' multiple intelligences (Gardner, 1983) by providing experiences designed to encourage genuine learning. Gardner's theory emphasizes authenticity in scheme construction. It is a theory, when applied to practice, which promotes addressing an array of seven distinct intelligences. Therefore, students invoke their intelligences in music, personal and social interaction, linguistic skills, individual movement, mathematics, and spatial relations. Now students have a seven-fold opportunity to organize their learning process scheme shaped around Bloom's Taxonomy.

In preparation for our college algebra class, we work on developing the kinds of strategies that demonstrate links between Gardner's theory and Bloom's Taxonomy, and elementary mathematical concepts. And it occurred to us that we could exploit our interest in blues music to assist us in making that connection between Gardner and Bloom. In fact, we decided to compose an original blues tune, a tune that we would use as our catalyst in the linking of Gardner to Bloom. We will engage our students' varied intelligences in order to minimize their math anxiety and help them to gain a better understanding of basic mathematical concepts.

In a nutshell, as we prepare for our college algebra course, we sing the blues, "The Hierarchy Blues." Accompanied by our trusty harmonica (in the key of C), we sing:

THE HIERARCHY BLUES

(chorus)

The hierarchy blues

The hierarchy blues

You know I got the hierarchy blues

The hierarchy blues

The hierarchy blues

You know I got the hierarchy blues

Bloom gives me a pain

In the cognitive domain

Don't forget the affective and psychomotor too

Bloom gives me a pain

In the cognitive domain

Don't forget the affective and psychomotor too

(cognitive domain refrain)

The cognitive has thinking skills

Six from low to high

Plan your lessons right

Your kids will reach the sky

(affective domain refrain)

The affective has attitudes

And it has values too

A low of one -- a high of five

Kids learn but don't feel blue

(psychomotor domain refrain)

Psychomotor it has seven

It gets real physi-cool

It shows how kids play out a task

To do their best in school

(chorus)

The hierarchy blues

The hierarchy blues

You know I got the hierarchy blues . . .

Mathematics Classroom Activities

The previously discussed constructivist approach to education manifests itself in a variety of ways in our mathematics classroom. We engage the students in many types of activities, not limiting ourselves to the traditional lecture or skill and drill styles of mathematics education. Our activities engage the students' various intelligences.

For one activity, we demonstrate how mathematical functions work by using the students as points on a graph. In order to do this, we go outside, and one student acts as the function, while the other students are assigned "x-values." The student who plays the role of the function then takes each student and assigns them an "f(x) value," according to their predetermined "x-value." The students then takes the appropriate number of paces along both the x and f(x) axes, until they reach their points on the graph. This activity, unlike methodologies used in traditional mathematics classrooms, utilizes the students' kinesthetic and social intelligences (interpersonal and intrapersonal combined).

As another activity, our students have the opportunity to write reports on various mathematical topics, often in collaboration with a partner, and then present their findings to the class. The composition of these projects involves our students' linguistic, logical, and social intelligences.

As another example, we treat mathematics as a foreign (but soon to be familiar) language in the classroom. This appeals to the students' verbal intelligence. We often "translate" seemingly complex mathematical statements into English, thus allowing the verbally inclined learners in the class to more fully grasp the material. For instance, the mathematical statement $f(x) = 7x - 9$ can be translated as "I've got a mathematical machine called 'f'. This machine's job is to take whatever I give it, multiply it by seven, and subtract nine from that." Such translations allow students to view mathematics in terms that may be more familiar to them.

Along the same lines as the last example, enrichment activities are also carried out in the classroom. One activity that effectively stimulates both class discussion and students' verbal learning skills takes place in our introductory statistics class. In statistics, parameters are typically given Greek letter names, while statistics are typically given names using the letters ordinarily seen in the English (as well as many other Western European) language. Early in the semester, we have our students investigate the origins of the alphabet used in the English language. Not only does this task directly tie in to the statistical concepts at hand, but it also allows the students to gain an appreciation for language and the interrelationships between languages.

As can be seen from the examples given above, the students in our introductory level mathematics courses have the opportunity to learn mathematics in many different ways. This allows each student, no matter what type of learner he or she may be, to absorb the material in whatever way is most natural for them. The utilization of multiple intelligence theory in our classroom has a twofold affect. First, our students are able to more easily master the concepts and applications within the course, by using a broad array of their intelligences. No longer is the mastery of quantitative methods the sole domain students who are gifted with great mathematical-logical intelligence. Second, the inclusive and relaxed setting that exists in our multiple intelligence oriented classroom reduces the level of math anxiety that our students experience.

The two aforementioned outcomes do not occur in isolation of each other. There is a feedback loop between the two. The reduced level of anxiety allows students to more effectively utilize each of their intelligences, while the activation of many different intelligences reduces our students' anxiety levels.

Preliminary Analysis

As previously noted, over 80% of the students who initially register for the introductory mathematics classes that we teach using the previously discussed methods both remain in the class for the entirety of the semester and successfully complete the course with a grade of "C" or better. This failure/drop rate of 20% is less than half of what is seen in more traditional classrooms (http://faculty.valencia.cc.fl.us/srobinson/papers/remediat.htm).

A survey of students in our introductory statistics course bears out the predictions contained within this paper. Twenty-one students in a typical introductory statistics class were sampled. The students were asked the following questions:

1. How well do you feel this particular math class addresses your own individual style of learning?
2. How well do you feel the average math class addresses your own individual style of learning?
3. How likely do you feel you are to succeed in this particular math class?
4. How likely do you feel you would be to succeed in an average math class?
5. How much have you learned in this math class?
6. How much have you learned in your average math class in the past?

The students answered each question on a scale from zero to ten, and sample means, m_1 through m_6 respectively, were calculated for each of the six survey questions. The sample means are presented in table 1 below.

Question	**Sample Mean**
1. How well do you feel this particular math class addresses your own individual style of learning?	9.00
2. How well do you feel the average math class addresses your own individual style of learning?	6.29
3. How likely do you feel you are to succeed in this particular math class?	9.67
4. How likely do you feel you would be to succeed in an average math class?	7.19
5. How much have you learned in this math class?	9.38
6. How much have you learned in your average math class in the past?	6.90

Table 1

The differences in the paired sample means are given in table 2 below.

Paired Sample Means	**Difference**
$m_1 - m_2$	2.71
$m_3 - m_4$	2.48
$m_5 - m_6$	2.48

Table 2

Given the moderate size of the sample (n = 21) and no extreme departures from normality, it was determined that t-tests could be utilized to analyze the difference in the sample mean. Three paired t-tests (corresponding to the three paired differences in table 2 above) were conducted using Microsoft Excel's data analysis options, at the 5% level of significance. The hypotheses tested were as follows.

Hypothesis 1:
H_0: $m_1 - m_2 <= 0$
H_a: $m_1 - m_2 > 0$

Hypothesis 2:

H_0: $m_3 – m_4 <= 0$
H_a: $m_3 – m_4 > 0$

Hypothesis 3:
H_0: $m_5 – m_6 <= 0$
H_a: $m_5 – m_6 > 0$

In each case, conclusive evidence was found of a non-zero difference between the means, in the direction of the alternative hypothesis. The p-values were 0.000064, 0.000011, and 0.000010, respectively. It should be noted that each of these p-values is far below the 0.05 threshold for statistical significance.

These findings imply three things. First, the constructivist approach utilized in our classroom addresses students' individual learning styles better than the traditional approach. Second, our pedagogical approach enhances students' self-efficacy in mathematics and statistics, in comparison to their expressed self-efficacy in traditional classrooms. Third, the approach we utilize results in the acquisition of greater skill in mathematics and statistics than they would have in a traditional classroom.

Conclusions

Enlarging our sample size is a primary objective for further study of our topic. We plan to continue to quantify the implications of this study regarding the instructional effectiveness of recognizing that multiple intelligence theory makes connections between the contemporary and the classical approaches to assessment that are used in mathematics education. By adding eight sections of elementary mathematics classes, numbering some twenty students per section, to the original group in this study, we intend to examine a practical assumption. Namely, we shall verify that when mathematics students engage their multiple intelligences, the process enables them to acquire the knowledge and skill needed to link mathematical applications to basic mathematical theory. Our expectation is that first year college mathematics students will be prepared to enter their chosen majors and professions with an ability to align their mathematical skills with the quantitative tasks set before them in the world of work.

REFERENCES

Ashcraft, Mark H., and Kirk, Elizabeth P. (2001). The Relationships Among Working Memory, Math Anxiety, and Performance. Journal of the American Psychological Association, 130, 2, 224-237.

Banks, J., and Banks, C. (1989). Multicultural Education: Issues and Perspectives. New York: Allyn and Bacon.

Bloom, B. S., Englehart, M.B., Furst, E.J., Hill, W.H., and Krathwohl, D.R., eds. (1956). Taxonomy of Educational Objectives. New York: McKay.

Brooks, J. G. and Brooks, M.G. (1993). In Search of Understanding: The Case of Constructivist Classrooms. Alexandria, Virginia: Association for Supervision and Curriculum Development.

Dewey, J. (1938). Experience and Education. New York: Macmillan.

http://faculty.valencia.cc.fl.us/srobinson/papers/remediat.htm

Gardner, H. (1983). Frames of Mind: The Theory of Multiple Intelligences. New York: Basic Books.

Hyerle, D. (1996). Visual Tools for Constructing Knowledge. Alexandria, Virginia: Association for Supervision and Curriculum Development.

Piaget, J. (1950). The Psychology of Intelligence. London: Routledge and Kegan Paul.

Sagona, James. Neumann College Faculty Senate Meeting, 7 October 2003. Personal communication.

Savitz, R., & Savitz, F. (2005). Proceedings of the 2004 International Diversity Conference.