

**Learn by Teaching:
A Mediating Approach to Teaching and Learning Mathematics for Prospective
Teachers**

by

Hamide Dogan-Dunlap
Mathematical Sciences
University of Texas at El Paso
hdogan@utep.edu

Jeffrey Dunlap
Jeffrey.dunlap@sbcglobal.
net

Elena Izquierdo
Olga Kosheleva
Teacher Education
University of Texas at El Paso
ielena@utep.edu
olgak@utep.edu

Abstract

A mediating approach is implemented into a section of Block I courses elementary pre-service teachers took in a cohort setting in Spring 2002. The paper discusses the components of the approach as well as the logistics of the initial implementation. Furthermore, the paper provides qualitative and quantitative analysis of a set of data gathered from a section of Spring 2002 Block I courses. The results indicate that a set of mediating activities similar to that of the ICFB approach may result in changes on prospective teachers' attitudes toward and perceptions of mathematics as well as their performance in mathematical tasks.

Introduction

Low self-esteem and mathematics phobia may result in confused thinking, disorganization, avoidance behavior, and passivity. Furthermore, it has been reported that students' attitudes, perceptions and beliefs may have a strong influence on students' evaluation of their own ability, and on their willingness to engage in mathematical tasks hindering one's performance on higher-level cognitive tasks (Conte, 1991; Garofalo and Lester, 1985; Garofalo, 1989; Mandler, 1989; McDonald, 1989; NCTM, 1989; Tobias, 1993; Zentall & Zentall, 1983). For instance, a student considering mathematics as a bunch of symbols and procedures may choose to memorize facts, and may not put any effort to understand "whys." Moreover, a student with a negative perception of the role of mathematics in his/her future profession may decline to participate in mathematics activities (Pintrich, Marx, and Boyle, 1993).

There have been reports of similar behaviors and emotions among pre-service teachers (Ambrose, 2004; Battista, 1994; Smith, 1964). Many pre-service teachers are reported to reflect more of a subject that is all about symbols, equations, formulas and procedures that are to be memorized, and a perception conflicting with the one that supports the role and the importance of mathematics in EC-4 teaching. Even though pre-service teachers display a potential to learn and do well in mathematics, high mathematics anxiety and pessimistic beliefs they hold seem to divert the attention of many from content learning to self-esteem issues, which consequently seem to deteriorate their cognitive processes (Mandler, 1989; McDonald, 1989; Tobias, 1993). It is clear that there is a need to address these attitudinal, belief, and anxiety issues before expecting meaningful participation in mathematics activities. McDonald (1989) states:

It is only by changing the environment to accommodate emotional and motivational reactions to mathematics that we can change students' willingness to withstand frustration, errors, and failure. (p. 232)

Some (if not all) of the affect factors (factors that entail emotions, beliefs, attitude, etc.) might be reshaped through a set of mediating learning activities (Ambrose, 2004; Dogan-Dunlap, 2006; Fennema, 1989; Gray, 2001; McDonald, 1989). For instance, one may address confidence issues through collaborative group activities where students are actively involved in the process of investigation, conjecture and generalization (Fennema, 1989). This may increase one's understanding resulting in a positive change in attitude toward mathematics, and an increase in meta-cognitive skills leading to higher confidence. Furthermore, the absence of beliefs about the importance and usefulness of mathematics might be addressed by providing learning opportunities for students in order to experience the use and the importance of the subject.

A set of mediating activities as part of a pedagogical approach, *An Integrated, Collaborative, Field-Based Approach to Teaching and Learning Mathematics (ICFB)* (see figure 1), has emerged as a result of discussions between mathematics and education faculty. The approach has come about to address the affect factors our pre-service teachers appeared to hold, and consequently advance their mathematical knowledge. It is expected that a high confidence in one's ability to do mathematics results in a positive attitude, thus an increase in motivation. In return, a positive change in attitude and an increase in motivation will result in a higher confidence. In the long term, pre-service teachers with enhanced content knowledge and higher confidence may graduate highly motivated, mathematically literate students.

The ICFB Approach to Teaching and Learning Mathematics

Currently, there exist two field-based block structures at our University: Block I and II. Block I consists of three courses, two of which focus on mathematics. Teachers take the three courses as a cohort during the first semester of their last year in the program. Block II offers three courses with science concentration taken during the second semester. The ICFB approach is integrated into a section of Block I courses. The two education courses in Block I consist of pedagogy (this has been recently replaced by a social studies course) and the mathematics methodology at elementary and middle school levels. The third course is a mathematics content course. In the past these courses were taught in isolation with little to no collaboration between the education and the mathematics faculty. Students have repeatedly complained about the inconsistent teaching practices. The teacher lecture mode implemented in mathematics content course has been inefficient in addressing pre-service teachers' learning difficulties, and their needs.

The ICFB approach includes activities that are developed to support various components of the cyclic process of Learn, Develop, Practice, Reflect and Teach, which is modified from another approach that was at the time implemented into a Block I section with prospective middle school teachers. Figure 1 outlines the activities of ICFB and the involvement level of the three courses as well as the roles of block instructors, in-service teachers and elementary schools. For instance, the bubble with

“LEARN/Math/Methods” indicates that the learning of mathematical concepts mainly occurs as a result of a collaboration between the mathematics content and methodology courses. It also implies the existence of common assignments and requirements between the two courses.

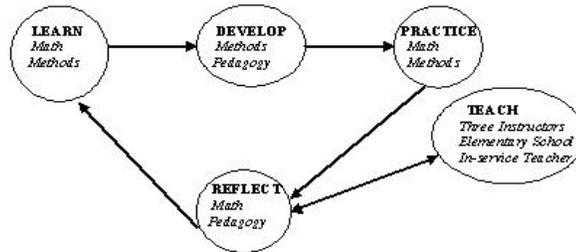


Figure 1. Diagram of the ICFB Approach to Teaching and Learning Mathematics implemented in Block I courses with elementary prospective teachers. Adopted from an approach implemented in a middle school block.

Block Courses

Mathematics content and methods courses

The mathematics content course meets twice a week, once on campus in a classroom where the methods course meets, and again at an area elementary school right after or before the pedagogy course again in a common classroom. Methods and pedagogy courses meet once a week. Table 1 shows the block schedule of the three courses from spring 2002.

Table 1: Block schedule of the three courses from Spring 2002.

	Tuesday	Thursday
Pedagogy	8:00-10:30 Elementary School Classroom	
Mathematics Methods		8:00-10:30 EDU 401
Mathematics Content	11:00-12:20 Elementary School Classroom	11:00-12:20 EDU 401

The instructors of both the content and methodology courses facilitate student learning through active, inquiry-based and collaborative group projects. Students are introduced to and work on the mathematics content projects during the content hours. They continue to discuss the same or similar topics in the context of teaching and learning at the EC-8 grade levels during the methods hours. For instance, after completing another project where pre-service teachers gained an experience with the illustration of the process and the results of basic fraction operations, they worked on a content project called “Sandwich Problem” (see Appendix for the project statement). The Sandwich Problem was given to provide learning opportunities for students to gain a deeper understanding of “invert and multiply” procedure. While working on the particular project, during the method hours, our students studied basic fraction operations this time focusing on the teaching and learning of the concept in an elementary and a

middle school mathematics classroom. In short, the difference between the two courses is that the content mainly emphasizes the advancement of pre-service teachers' mathematical content knowledge, and the method course focuses more on the best practices in the teaching and learning of mathematics concepts at the EC-8 level.

Methods and Pedagogy courses

Even though the methods and pedagogy classes do not have the same meeting day, they use their class time to facilitate and support the process of micro-lesson development. These are short lessons covering topics modified from the mathematics content projects for the K-4 grade levels. Students initiate the process in the methods course, and continue their work during the pedagogy hours receiving constructive feedback and support from both instructors. The main focus of the pedagogy course is on the State Professional Development (PD) standards. Mathematics is considered as the core subject while discussing the PD standards. Upon the development of the lessons, approximately one week before the actual classroom teachings, students use both the mathematics content and methods hours to practice their micro-lessons.

Mathematics content and Pedagogy courses

Meetings at a site elementary school integrate both the mathematics content and pedagogy courses. Both courses use some of their time for reflections on micro-lessons and actual micro-teachings. For instance, pre-service teachers are encouraged to discuss classroom management issues in the context of their experiences gained during their micro-teaching and internship hours. Pre-service teachers are required to have field experiences through an internship in a local elementary or middle school classroom during the days where there is no class meeting.

Micro-Teachings

There are about four teachings, about one per month, lasting approximately 30 minutes (accordingly, named micro-teachings). The number may however vary from one block section to another. The middle school block from spring 2002, for instance, required one micro-teaching per week. Elementary pre-service teachers teach the first three micro-lessons in groups of four to six in their designated elementary classrooms at a designated elementary school where the content and pedagogy courses meet. The last micro-teaching is carried out individually at internship schools, and is presented during final weeks.

The in-service teachers of the elementary classrooms become the mentor teachers for the prospective teachers, providing continual feedback on their teaching. At least one of the block instructors is also present during micro-teachings. The micro-teachings take place mainly during the content and pedagogy meeting hours for the convenience of both block instructors and pre-service teachers since both courses meet at the designated elementary school.

Overview of the ICFB Approach

The following outlines the essential components of the ICFB approach:

- Cohort, Field-Based nature of Block I.

- Mathematics as the common theme for Block I courses.
- Common assignments and requirements.
- Instructor participation in Block activities.
- Active, constructive and collaborative learning in Block courses where instructors become facilitators and guides but not authorities.
- Mathematics concepts are learned through inquiry-based mathematics content projects.
- Micro-lessons are developed based on mathematics content projects.
- Micro-lessons are practiced.
- Micro-lessons are taught in actual elementary classrooms.
- Elementary schools and in-service elementary school teachers are involved as providers and supporters.
- Constructive feedback is provided on common assignments, micro-lessons and micro-teachings, and on issues ranging from content mathematics to classroom management.
- Micro-lessons are taught individually and presented during finals week to demonstrate an ability to integrate content, methodology and pedagogy knowledge covered throughout a semester.

How did the ICFB approach Come About?

Our collaboration started in fall 2001 when one of the authors of the paper joined the university, and began teaching the content component of a Block I section. Through out the semester, the author sat in on the other two education courses and participated in activities. During this time, observing many commonalities between the courses, she initiated an ongoing discourse between the three Block instructors. At the time, the Block courses were taught in isolation with no collaboration, even though prospective teachers were taking the courses as a cohort. This discourse led to a common assessment: the presentation of the final and the only micro-teachings that were already required by the pedagogy faculty. These assessments were to be taught at prospective teachers' designated internship schools. Initially, the instructor did not specify a topic/theme for the lessons. Topics could vary. Later, mathematics was agreed to be the core subject of the lessons along with the integration of other subjects. For instance, one of the pre-service teachers from fall 2001 semester prepared a lesson on measurement and geometry that also integrated geography. The lesson had elementary school students measuring distances and areas on a U.S. map while recognizing and discussing various locations

with significance. Experiencing the increased excitement of many of our teachers during the semester, and anticipating the potential positive effect on motivation (especially with mathematics activities), it was decided to continue the collaboration the following semester.

The three instructors requested and were granted the same Block I section during spring 2002. Initially, the three faculties agreed to share teaching responsibilities by fully participating in the block activities. For example, the content instructor was to attend pedagogy and methods courses and actively participate in their activities, although not teaching the content. The designated instructor of each subject was to deliver the content. Full participation in block activities turned out to be difficult due to the course load and other responsibilities of faculty. One was teaching four courses, and the other faculty had administrative duties while teaching two courses. The content instructor was the only one who could visit the courses and participate actively. In addition, since the content course met twice weekly after both the pedagogy and methods courses, its instructor naturally took on the responsibility of coordinating common assignments between classes, and the scheduling of micro-teachings. This instructor also established and kept an on-going communication between the parties involved; block instructors, students, and the mentor teachers. The spring 2002 was a successful semester in implementing the ICFB approach, with very few problems encountered.

The fall 2002 semester was not as successful. The content instructor had to reduce the coordinating role and visited block classes less often due to increased responsibilities. In this semester, the ICFB approach was implemented with a few modifications. Communication among the block instructors was established via email after a couple of in-person meetings at the start of the semester. As a result, there was less communication among students and the elementary school in-service teachers. This time, the pedagogy faculty took on the scheduling of micro-teachings. The mathematics methods instructor was again teaching four courses which made it difficult for her to take on an added responsibility.

Students' evaluations, their pre- and post-survey statements, and instructor observations indicate that the successful implementation during Spring 2002 might be attributed to the fact that there were notably more classroom visitations and higher participation among block faculty, which led to consistency between the courses on the ideas discussed and assignments covered. Moreover, this caused an increase in students' appreciation of how these courses can be effectively integrated, with many of the students coming to realize that mathematics is not an isolated subject. However, student responses and instructor observations from fall 2002 indicate that diminished faculty participation led to a lack of unified vision. This resulted in a decrease in the number of students actively participating in mathematics activities in fall 2002.

During Spring 2003, a change in personnel assigned to teach the block courses resulted in more divergence between teaching styles, especially with respect to mathematics. The lack of a common vision meant that even with a modified ICFB approach, from the students' perspective, the courses were not sufficiently linked. An example can be found in the following excerpt from a Spring 2003 student comment in an end of semester post-survey:

Team teaching sounds like an attractive concept, however I do not think it's necessary. The courses don't really need to be taught together... [Pedagogy instructor]'s class does not seem to be related to [Mathematics content instructor]'s & [Mathematics Methods instructor]'s class, so why are they joined?

Diminished faculty participation, the lack of communication, and no common view seemed to give pre-service teachers conflicting messages. This led to heightened frustration among students, and is reflected as decreased motivation, not only in mathematics content activities, but in all the components of the ICFB approach. This implies the necessity of establishing a set of common expectations, and a common vision for the Block. The authors believe that this can be achieved through ongoing, frequent communication and compromise.

Since the mathematics content course met once a week at an elementary school site, some of its hours had to be used for classroom visits and micro-teachings. This resulted in the coverage of fewer content projects. The instructors believed that the mathematics methods course is the natural course to be used for these activities. Since the focus of the course is on the instructional practices in teaching and learning mathematics concepts, students can be exposed to and learn about various instructional practices during classroom visits and micro-teachings. Most of the time, these method hours were not able to be used due to the fact that the course was scheduled to meet on campus. Scheduling mathematics methods at elementary school site and using its hours for micro-teachings should resolve the issue of mathematics content coverage.

The remainder of the paper will provide and discuss the findings of an ongoing study investigating the potential effect of the ICFB approach on students' attitude toward and perception of mathematics as well as their performance.

Methodology

Data

A set of pre- and post-surveys was collected from a group of pre-service teachers (N=29) who experienced the ICFB approach in Spring 2002. Both pre- and post-surveys consisted of the same questions on feelings about and experiences with mathematics, and the Block courses. A copy of the pre-survey can be found in the Appendix. One of the questions asks students to address the question, "What is mathematics?," including the experiences they have had with the subject. The responses for this question were analyzed to determine students' perceptions of mathematics as well as their beliefs and emotions toward mathematics. After one of the authors and two graduate MAT (Master of Arts in teaching in mathematics) research assistants independently read and reread students' responses, various common themes emerged and categorizations were made accordingly. The two main categories are (1) responses revealing emotions and (2) responses providing definitions. Beliefs, attitudes, and confidence related responses were included in the emotion category. Statements providing non-emotional components of mathematics were considered in the definition category. For instance, the statements "math is about numbers," and "math is used every day" are counted as definition-related. It should however be noted that there were responses that included both emotion and definition related statements. The percentage reported in each category indicates the percent of students who included category relevant statements on their responses. These

percentages are reported in the remainder of the paper. As the representative of the majority of student opinions, excerpts from responses on post-survey questions about the nature of the Block courses are also shared to shed further light on the effectiveness of the ICFB approach.

Results

Pre-survey

The pre-survey was administered in a spring 2002 block during the first week of classes as homework. The findings from the pre-survey indicate that the majority of pre-service teachers, most of whom are Hispanic (approximately 85%), come into mathematics courses with negative attitudes and the fear of the subject, as well as low confidence in their ability to learn mathematics and think mathematically. The following three excerpts typify the responses of the majority of pre-service teachers:

Math is a fear I have not been able to conquer. The fear of math has put a block on my brain. I don't like math because I feel very dumb when after so many years I still don't comprehend it.

From my personal experiences with math, I was taught to drill and skill. Not only was I "tortured" at school in that manner, but I'd come home and have to recite addition, subtraction, multiplication, and so on. In all honesty, I learned to dislike math very much.

No idea of def[inition] of math; it usually means lots of time consuming HW; never liked math, but we need some amount of it to know how to solve everyday problems.

All three responses reveal strong emotional reactions, low confidence and negative attitudes towards mathematics. The first response is an example of how a strong emotional reaction toward mathematics can stop one's cognitive processes and leave the person feeling less competent about his/her ability. The second response reveals some of the reasons why this person began to dislike mathematics. The third person's response reveals dislike and a belief that mathematics is about time consuming homework, implying that the time spent for mathematics is wasted. For all three, mathematics seems to be primarily a subject with high negative emotions attached.

In fact, this is the case for the majority of the pre-service teachers in the group. Approximately 80% of prospective teachers included emotional factors in their definitions on the pre-survey. Fifty-nine percent displayed negative emotions, 33% felt mathematics was a difficult subject, and another 38% included statements revealing low confidence in their ability to learn mathematics. About 85% included non-emotional aspects of mathematics in their responses. Of the 85%, one-fourth indicated a perception of mathematics as a subject that is used to solve problems. Another 26% emphasized its help in understanding real life problems or the necessity to have a good understanding to further one's mathematical knowledge. Fifteen percent indicated mathematics as being all about symbols, equations and formulas. Another 15% of students indicated that they

believe mathematics involves logical (or critical) thinking and reasoning. See figure 2 for a graphical display of the results.

Post-Survey

The post-survey was administered during the last week of Spring 2002 semester as homework. It consisted of the same questions as those in the pre-survey with a few additional questions on students’ opinion of the Block courses. Contrary to the 80% on the pre-survey, of the forty-six percent whose statements contained emotional factors, 35% (59% on the pre-survey) stated negative emotions, and 15% indicated that learning mathematics is difficult for them.

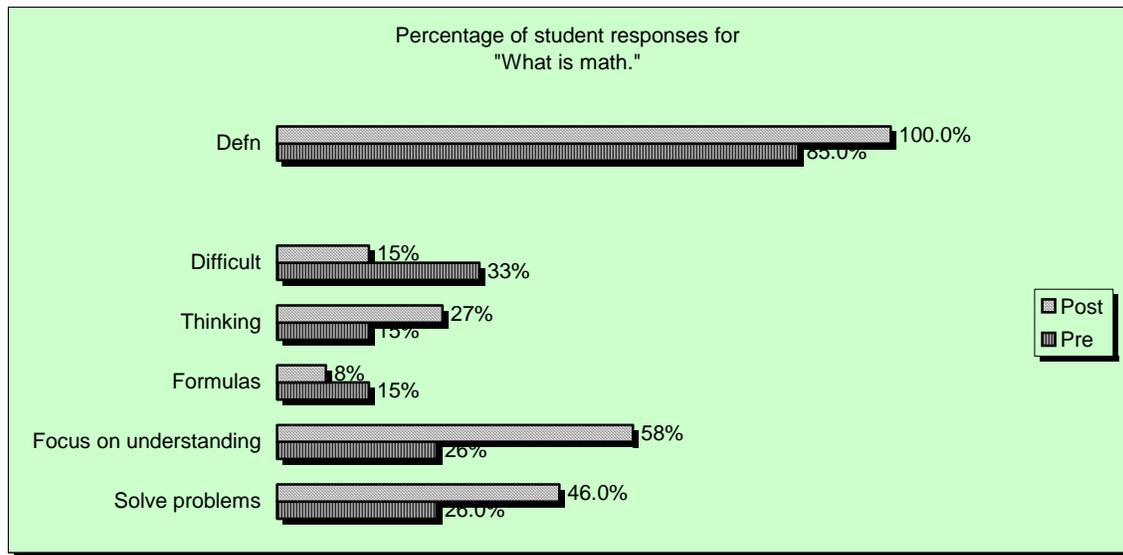


Figure 2. Pre-service teachers’ responses from Spring 2002 pre- and post-surveys on the “what is mathematics” question.

Among the non-emotional responses, 46% indicated the problem solving aspect of mathematics and 58% emphasized the necessity of a deeper understanding of mathematics concepts. There was approximately an 8% decrease from pre- to post-survey on responses indicating that mathematics is all about symbols, equations and formulas. Approximately twelve percent more teachers (27%) considered mathematics as a subject requiring logic and reasoning from pre-survey to post-survey. In addition, about ten percent of the group included post-survey responses with statements on the pattern finding aspect of mathematics. On the other hand, the pre-survey did not have any responses with similar statements.

Pre-survey vs. Post-survey Responses

Figure 2 outlines the changes in a group of pre-service teachers’ attitudes toward and perceptions of mathematics after experiencing Block courses with the ICFB approach. At the end of the Spring 2002 semester, compared to the number of similar responses on the pre-survey, notably more students stated that:

- Mathematics is used (or a tool) to solve problems.

- Mathematics is helpful/necessary to understand real life problems/issues and it is important to have a deeper understanding in mathematics as opposed to memorization.
- Mathematics involves logical or (critical) thinking and reasoning.

Furthermore, noticeably fewer teachers reported that:

- Mathematics is all about symbols, formulas and equations.
- Mathematics is difficult.

The decreasing number of prospective teachers who considered mathematics as a difficult subject might be interpreted as an increasing number of our teachers gaining confidence in their ability to learn mathematics and think mathematically. In addition, the smaller quantity of students stating mathematics as being about symbols, formulas and equations might be attributed to more of those considering the subject as something that involves thinking and reasoning and not memorization of meaningless formulas and equations.

Another notable result is that all the students provided unemotional descriptions for mathematics compared to the percentage of those providing similar descriptions at the beginning of the semester. It was observed that these kinds of changes in students' perception and behaviors resulted in an increased participation in mathematics activities, thus resulting in an increase in mathematical knowledge.

Representative Post-survey Responses

As the representative of the majority of opinions, excerpts from the post-survey are provided to support the quantitative results reported above, and further document the effectiveness of the primary aspects of the ICFB approach.

Mathematics Content Course

The ICFB approach provided the motivation needed for students to increase their participation in mathematics content activities. During the Spring 2002 semester, notably more students began to voluntarily participate in activities and complete assignments. Many started to search for multiple explanations and representations. Furthermore, many of them stayed longer with the projects. They were more persistent on their investigation, conjecture, and generalization of their findings., and fewer of them showed frustration during the mathematics activities. Moreover, many began to take charge of their own learning instead of looking to the instructor for answers. The following excerpts from student responses on the post-survey reveal the nature of the mathematics content course, and provide supporting evidence for the student behaviors mentioned above:

This course makes me think and I feel challenged which is good. I like thinking out loud with my group and sharing our thoughts....

...I am also surprised at how much I am understanding and learning. Before I began this I was really dreading it.

My life experiences in my math have not always been great. When I first started this course the projects were overwhelming. Once I worked on several projects, I felt confident and comfortable to challenge them. I am

actually enjoying the course and learning to take advantage of my abilities to solve problems and to use my brain...

This course was exciting and allowed me to take a risk (something I have fear in math) in my thinking. I appreciate how I was respected and valued in my thinking...

...I believe this class is helping push toward my goal in being a good teacher.

Micro-Teachings

Many of the prospective teachers showed excitement about the micro-teachings. The experiences gained during micro-teachings made students realize the importance of mathematics in their profession. In turn, an increasing number of them became more receptive to mathematics activities. Furthermore, student experiences with micro-teachings changed their perception of what it means to learn mathematics and what mathematics entails. The following excerpts from post-survey responses reveal the nature of micro-teachings and the student behaviors described above:

Micro-teaching has been a learning experience for me. Our lessons have helped to introduce important math concepts that will be useful for the students. It has also helped me to see how important it is to be prepared when teaching a lesson...

I am enjoying the micro-teaching. I am constantly amazed by how fast some of the kids pick up on the concepts...

Very good experience. By working in groups each one of us can give each other feedback on the good & bad things of our teaching. Plus a teacher [block instructor] is there to observe us and also give us feedback.

I realized as I was teaching at my internship that we need to know how kids think as well as how to explain and approach to children about math concepts. I would like to explain to them so that they may understand as well as enjoy math.

The micro-teaching projects are helpful in that they are preparing us to teach mathematics and giving us practice in the classroom. I know that I need this because I have always been so weak in math and I don't want to carry this into my own classroom.

I was never very confident in my mathematical abilities, but that changed dramatically ... after teaching in a 2nd grade I realize that not everyone can learn a new math concept in the same way and I understand now that I must find a variety of ways to teach the same concept. Math requires

patience, exploration and an open mind. My attitude towards math has changed because I now realize that math can be fun.

Integration of the Courses

The collaboration and common assignments between courses helped decrease the stress and anxiety level that students displayed toward the block courses, and especially toward mathematics at the start of the semester. The following excerpts reflect the nature of the collaboration between the block courses, and the student behavior described above:

The team teaching works well, because all three professors help us look at the material in different ways. I like the fact that we usually work on the same project [meaning assignments] for all three courses.

I enjoy it. I have much less to duplicate and juggle with these courses combined.

I think this is great. This is probably one of the most stress free semesters I have had in a while. I feel like it is just one class to me...

Common Expectation, Vision and Consistency

Two excerpts from the post-survey responses reveal how much value and appreciation students may have had for consistency, common expectations, and a common vision/philosophy. In addition, the excerpts provide implicit hints on how important these aspects were for pre-service teachers to feel the effectiveness of the integration between courses:

I would like to say that all three teachers are asking for the same common ground which is comprehension of the information whether it be math, planning a lesson or understanding classroom management.

You do not have to worry a lot about working on something different for each teacher and not see a connection. They also are flexible on the work and it is not busy work...

Conclusion

The paper discussed the results of an analysis of the Spring 2002 data documenting changes in prospective teachers' attitudes, perceptions and performance in mathematics after experiencing the ICFB approach. The results provide evidence that is in agreement with the authors' experiences and observations. The guided, inquiry-based and collaborative group work appeared to help pre-service teachers gain confidence in their ability to learn mathematics and think mathematically. In turn, this resulted in a change in their perception of mathematics, from that of a subject being all about symbols, equations and formulas to be memorized, to a subject that requires logical thinking, reasoning, investigation and discovery. Moreover, the micro-lessons and micro-teachings in actual elementary classrooms provided opportunities for students to experience the importance and the necessity of knowledge and a deeper understanding of elementary and

higher mathematics in accurately and effectively responding to a variety of questions EC-4 students may pose. Consequently, these experiences resulted in positive changes in the students' attitude toward mathematics. The authors believe that this came about due to the successful implementation of the ICFB approach.

In short, positive changes in behavior, emotion and perception can motivate preservice teachers to fully participate in mathematics content activities, and as a result become more confident in their ability to do mathematics. The higher confidence in turn may result in positive changes. Thus, the findings reported indicate that these changes may be obtained through a set of mediating activities similar to that of the ICFB approach.

References

- Ambrose, R. (2004). Initiating change in prospective elementary school teachers' orientations to mathematics teaching by building on beliefs. *Journal of Mathematics Teacher Education*, 7 (2), 91-119.
- Battista, M.T. (1994). Teachers beliefs and the reform movement in mathematics education, *Phi Delta Kappan*, 75, 462-463.
- Conte, R. (1991). Attention disorders. In B. Wong (Ed.), *Learning about learning disabilities* (pp. 60-103). San Diego: Academic Press.
- Dogan-Dunlap, H (2006). Pre-service Teachers' Attitude Toward and Perception of Mathematics: Case of a pedagogical approach to teaching and learning. *Proceedings of the Third International Conference on the Teaching of Mathematics (at the undergraduate level)*. Istanbul, Turkey. Paper number 430. 6 pages.
- Fennema, E. (1989). The study of affect and mathematics: A proposed generic model for research. In McLeod and Adams (Eds.), *Affect and Mathematical Problem Solving*, 205-220.
- Garofalo, J. (1989). Beliefs and their influence on mathematics performance. *Mathematics Teacher*, 83, 502-5.
- Garofalo J. and Lester F. K. (1985). Metacognition, Cognitive Monitoring, and Mathematical performance. *Journal for Research in Mathematics Education*, 19, 134-41.
- Gray, K.C. (2001). Changing classrooms by treating teachers as active learners. *Middle School Journal*, 32(3), 15-19.
- Mandler, G. (1989). Affect and learning: Causes and consequences of emotional interactions. In Douglas B. McLeod and Verna M. Adams, (Eds.), *Affect and Mathematical Problem solving: A New Perspective*. Springer-Verlag New, pp. 3-20.
- McDonald, B.A. (1989). Psychological conceptions of mathematics and emotion. In Douglas B. McLeod and Verna M. Adams, *Affect and Mathematical Problem Solving: A New Perspective*, Pp. 220-234.
- National Council of Teachers of Mathematics. (1989). Curriculum and Evaluation Standards for School Mathematics. Reston, VA: Author.

Pintrich, P.R., Marx, R.W., and Boyle, R.A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, 63(2),167-199.

Smith, F. (1964). Prospective teachers' attitudes toward arithmetic. *The Arithmetic Teacher*, November, 474-477. [NOTE: look up this volume & issue number online]

Tobias, S. (1993). Overcoming math anxiety. *The Nature of Math Anxiety*. New York: W.W. Norton & Company.

Zentall, S.S., & Zentall, T.R. (1983). Optimal stimulation: A model of disordered activity and performance in normal and deviant children. *Psychological Bulletin*, 94, 446-471.

Appendix

Note: Space provided for student responses is not reflected here.

Pre-Survey

Spring 2002

Block:

Name of M2303 instructor:

For future research on testing effectiveness of different instructional approaches, the following information card and questionnaire have been requested . Please respond to each item as correctly as possible to the extent of your knowledge. Your input will help us understand the effect of team teaching approach we will be applying to our block on learning and teaching.

Please print your responses.

First Name:

Last Name:

E-mail address (include the e-mail address you have been using actively):

Specializing in:

Mathematics and Education courses taken at UTEP, and letter grades obtained in these courses. Indicate the ones you have enjoyed taking by putting a check mark next to it.

Mathematics and Education courses taken at other college or universities, and letter grades obtained in these courses (Indicate the name of the college or university you have taken these courses from). Indicate the ones you have enjoyed taking by putting a check mark next to it.

State how often you use technological devices such as computer and inter net and for what purposes:

Courses you are taking this semester (state name of the courses, not the course numbers):

Name of the internship school:

Name of the mentor teacher and her/his phone number, and grade level:

State in a paragraph why you chose to be a teacher:

In a brief personal essay, address the question, "What is mathematics?" Answer this question based on your own personal background, experiences, & education. Try to define mathematics as clear as you can based on your own experiences both in & out of school. Describe specific illustrative examples.

Draw a picture reflecting your perception of mathematics.

In a paragraph, state your expectations from each of the three courses (Math2303, ELED3302 and ELED3310) in the block:

State in a paragraph the ways you learn mathematics the best:

Project

“Sandwich problem”*

Math 2303

Dr. [Instructor’s last name]

Spring 2002

Sue’s mom has enough ingredients to make 5 sub sandwiches for a party that Sue is hosting. Sue has not invited any friends yet because she wants to make sure that there are snacks for her and each of the friends that she invites. The decision that Sue and her mom need to make involves what fraction of each sub sandwich should constitute a “serving” for Sue and each of the party guests.

1. First, they wonder how many servings there will be if $\frac{1}{2}$ of a sandwich is a serving.
2. Write the division computation that answers their question; attach either “sandwich” or “serving” as a unit label to each of the three numbers in your computation, and explain why this computation is appropriate for this context. Central to your explanation should be a brief description of the division concept being used (sharing or subtractive) and how the problem above involves that concept of division.
3. Write a multiplication computation that answers their question and briefly explain why this computation is appropriate for this context. (Because you “invert and multiply” is not a valid explanation!) Central to your explanation should be a brief description of what multiplication is all about (conceptually speaking) and how the problem above involves that concept.
4. Next, they wonder how many servings there will be if $\frac{1}{3}$ of a sandwich constitutes a serving. Repeat questions 2 and 3 for $\frac{1}{3}$ of a sandwich as a serving.
5. Next, they wonder how many servings there will be if $\frac{2}{3}$ of a sandwich constitutes a serving. Repeat questions 2 and 3 for $\frac{2}{3}$ of a sandwich as a serving.
6. Next, they wonder how many servings there will be if $\frac{3}{5}$ of a sandwich constitutes a serving. Repeat questions 2 and 3 for $\frac{3}{5}$ of a sandwich as a serving.
7. Repeat questions 2 and 3 one more time, now using the mathematical expression $\frac{m}{n}$, where m , and n are any whole numbers, to represent that fraction of the sandwich constituting a serving.

*Adapted from an earlier version of the Charles A. Dana Center Supporting and Strengthening Standards-Based Mathematics Teacher Preparation (S³MTP) Projects, Concepts and Algorithms: Invert and Multiply.” UT Austin, 2004.