Learner Centered Education
2004 Final Report

1. Project Name and Project Director's Name, Include mailing address, phone and e-mail address

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2. Brief Description of the Project:

In this study we are seeking to investigate how innovative instructional materials can help prospective elementary teachers develop a deeper understanding of mathematics. At the same time we wish to better understand how university faculty who have little background in elementary education implement these innovative materials. At the University of Arizona, elementary education majors take the two semester-long sequence *Understanding Elementary Mathematics*, MATH 302A and MATH 302B. Both courses are required by all elementary education majors and are taken prior to their methods and practicum experiences. For each course, three new lessons have been created and integrated into the course syllabus. All instructors and students used these syllabi. In Math 302A, students examined video and written examples of children who have invented their own procedures for solving arithmetic problems. The lessons were designed to get the prospective teachers to develop a broader understanding of concepts related to number and operation. In Math 302B, students used dynamic geometry software to investigate, hypothesize and learn about geometry ideas. In both classes, these lessons were designed to be more student-centered and facilitate the students' construction of their own knowledge. In order to facilitate the lesson implementation, the instructors attended training sessions at the beginning of the semester.

In order to develop a rich description of the lesson implementation and subsequent student activity, we videotaped the classrooms during times when the lessons are being taught. The videotapes were used to capture both whole class instruction and small group interaction. In order to develop a more thorough picture of the students' learning, we also collected students' work and artifacts that were generated during these lessons. These artifacts were copied for later analysis. We are also looking at the instructors' decision making, so we also conducted interviews with the instructors.

3. Goals, Outcomes, and Assessments

a. Goals and Primary Accomplishments:

Several goals were accomplished during this project. First, we developed and implemented course materials that further integrated learner centered principles in the

mathematics content preparation of future elementary teachers. We were able to examine student work to better understand the extent that these lessons were able to influence their conceptual understandings of the content. While the data highlighted aspects of students learning during the lessons, during our analysis we found that the critical piece was the information we gathered about the instructors and what they did with the lessons. Providing professional development for college instructors was a key goal of the project, but we still observed a wide diversity in the instruction. Our analysis of the data has given important information about the factors that support or inhibit the successful implementation of these lessons. This has helped us to better understand how to support future instructors who will use these lesson modules.

b. Outcomes and Assessments for each Goal:

We were able to examine student work to assess the emergent understandings that the students developed over the course of the lessons. We found that overall, students work exhibited conceptual understandings. In addition to examining students' work, we administered a pre and post test to measure some aspect of the students growth. We caution that, especially for the case of Math 302A where the lessons were spread over several weeks, it is difficult to attribute growth on these quantitative measures to the specific lessons that were introduced in this project. Nonetheless, we did identify growth in most of the classes.

In addition to this content measure, a beliefs instrument was administered to the Math 302a sections measuring their beliefs about children's thinking. This instrument examined seven belief categories: (1) Beliefs that mathematics is a web of interrelated concepts and procedures, (2) Beliefs that knowledge of applying a mathematical procedure is not the same as conceptual understanding, (3) Belief that understanding is more generative than remembering procedures, (4) Belief that learning procedures before developing conceptual understanding inhibits one's ability to learn concepts, (5) Belief that children can solve problems in novel ways, (6) Belief that children think about mathematics differently than adults, and (7) Belief that while learning mathematics, the teacher should let the student do as much of the thinking as possible. Gains were observed in all categories, the most significant being in categories (5) and (6). It is interesting to note that the smallest change was observed for categories (1) and (7). Considering that the focus of the study was integrating more learner-centered approaches to teacher education, this was a surprising result.

Our primary assessment of the lessons was through analysis of the video taped record of the lesson implementation. Some of this analysis is still on-going (see difficulties section) however we have some results to report, mostly from the work done in the 302A classes. While using the video tapes to examine the students' interaction during the lesson was of initial interest, we found that the more compelling story was with the instructors. We found that there was an incredible amount of diversity in the implementation of the lessons. First, while students were engaged in group work, the instructors interacted with the students in varying capacities. Some instructors used to

time to serve as a resource, choosing not to interact with the students at all unless asked a question by a student. Other instructors examined student work and engaged with the students primarily to correct mistakes or keep students on task. A few instructors moved between groups to question the students about their progress and to uncover their emergent understandings. Most of the instructors were in the first two categories. There was also a varying degree in the ways that instructors responded to students' questions. In some cases, the instructor responded to the student by asking further questions, while in other cases, the instructor directed the student by directly telling them the answer to the question. Some instructors, especially in Math 302A when asked about something related to children or elementary classrooms, were not able to answer the students questions at all.

Our more extensive analysis of the 302A classroom revealed a great diversity in the ways that these four college instructors implemented the lessons designed for this study. One of the primary distinctions between the instructors' implementations was in the way that they organized the class discussions. After the students examined the video clips, the instructors all asked the students to discuss their thoughts about what they saw. Two of the instructors consistently responded to the students with further questioning about their thinking. This was in stark contrast to the manner that the other two interacted with the students. This second group of instructors engaged with the students and gathered students' responses, sometimes writing these responses on the board, but did not follow up with further questioning. Their actions would best be described as cataloging responses rather than facilitating discussion. Even though the first group did more probing, it should be noted that in all four classrooms, during whole class discussion the discourse was almost entirely between the student and the instructor. While occasionally students would respond to each others points, none of the instructors actively had students question or respond to each other.

A second major theme that was observed in the discussions was the extent that the instructors directed the discussion to "big ideas" rather than focusing on particulars of individual strategies rather than connecting them to deeper ideas. The first group both organized the discussion so that the students would compare and contrast different strategies with the goal of illustrating fundamental mathematical ideas. As an example, in the first lesson that focused on children's strategies for addition and subtraction problems, after the first group of instructors asked students to compare and contrast these strategies, they both turned the students' attention to the place value structure of the strategies. The second group also had students compare and contrast strategies, but did not continue this to a discussion of how the children's use of a particular strategy evidenced differing understandings.

While significant differences were observed in the areas described above, there were also aspects of similarity among all the instructors. All of the instructors valued the children's strategies that were exhibited in the video clips, and all of them consistently expressed a belief that examining the children's strategies would be an effective way to discuss the material. At the same time, however, during class none of the instructors were able to engage their students when the questions concerned pedagogy, such as when a student

asks how the students learned the strategies that they used. When the discussion turned to pedagogical issues, the instructors could not engage the students in a discussion about the genesis of the children's strategies or where they might show up.

4. Problems or issues encountered

We encounter two significant problems during the project. Our intention was to have a combined workshop to initiate the new instructors to the lessons that were to be implemented in the 302a and 302b classes. Our intention was to hold this workshop two weeks before the semester began. Unfortunately, it became impossible to accommodate people's schedules to hold this workshop. Since only one of the new instructors to the course would have been able to participated, we decided it was necessary to cancel the workshop. We opted, instead, to hold regular meetings with the instructors during the semester.

The second problem, more critical problem, was our difficulties hiring a person to do the transcribing of the video tapes that we had. We hired two undergraduate workers to help us with transcribing the data. Unfortunately, both of these undergraduates had to quit and completed little of the transcribing that was needed. The timing of their departure was at a time when finding adequate replacements was difficult so finding a stable replacement for the undergraduates was problematic. Because of this, the principle investigators were required to do a majority of the transcribing themselves. Due to this, we had to lengthen our timetable and which made it impossible to complete all of the analysis.

5. Conclusions, Recommendations, and future directions:

Even though we found that students exhibited knowledge growth, we found that the varying ways that the instructors engaged with the students impacted the depth in which the ideas were explored during class. In many cases, it was apparent that lack of knowledge on the instructors' part inhibited their ability to interact with the students in meaningful ways. For instance, while instructors may understand the mathematical meaning behind a particular child's innovative strategy, some were unable to discuss with the students how this strategy is significant in terms of the child's mathematical development. As such, for many of the instructors these strategies were treated as a mathematical curiosity and not as something that fits in the natural progression of children's thinking. We also found that even though the lessons were created to help students develop their own understandings of the mathematical concepts, some instructors harbored a strong tendency to tell the students what they should be learning rather than developing the environment where these ideas will come to the students.

Based on the tremendous amount of diversity in the implementation of these lessons, it still remains to see what kind of professional development opportunities are going to support future instructors' use of these materials. In the context of this project, focusing on general pedagogical principles did not seem to have been enough to help the instructors implement the lessons in more student-centered ways. More focused attention must be paid to college instructors beliefs about teaching, especially as it regards the instruction of future teachers.

Even with the wide range in instruction, there was evidence in all the classes that students developed substantive understandings of the mathematics material.

6. Has this project led to sustainable change in your department/college? Describe:

The lessons that were developed in this project have now become permanent parts of the curriculum in Math 302A and 302B. Materials have been developed, and are under constant revision, to help future instructors implement these lessons successfully. Our goal is that every aspect of the 302A and 302B course has learner-centered principles at its core. We intend to use our work on these few specific lessons to form a platform on which we can continue to affect other aspects of the course.

7. Impact:

a. Have other faculty been affected by this project? X Yes ☐ No. If so, describe:
As listed above, all current 302A and 302B instructors will be integrating modified lessons into their course syllabus. In addition, new training materials have been adapted based on our analysis of the data to help facilitate the instructors' implementation of the new lessons.

b. Number of courses affected/involved
The focus of this project has been the two mathematics content courses that are required by elementary and middle school teacher candidates. We currently offer 6 sections of each course every semester.

c. Number of students affected
There are approximately 25 students in each section of 302A and 302B. In total, approximately 300 students are affected each semester.

8. Significant Outcome:

What was the most significant outcome based on learner-centered principles that occurred through your project?

One of the central outcomes of this project was the development of greater understandings of the process of what an instructor contributes to a learner centered environment. While the development of new learner centered lessons is important, we see that it is equally important to consider the instructors that are going to be implementing these lessons. We argue, then that more detailed work must be done in the area of professional development of college instructors, rather than focusing on lesson development. While professional development was a component of this project, we recognize now that it needed to play a much larger role. Little work has been done on the development of college mathematics instructors, especially in the case of instructors engaged in the training of future teachers. We feel that this work will be helpful in further research in this area.