

Learner-Centered Education Program
Arizona Board of Regents
INSTITUTIONAL SUPPORT FORM

Proposal Title: Learner-Centered Mathematics Education for Pre-Service Teachers

Institution: University of Arizona DEPT/Unit: Mathematics

Multi-Campus/University Projects
(check other campuses or universities participating)

List other participating agencies:

ASU Main UA

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Briefly describe the program and the development plan.

We propose 3 strategies to educate prospective teachers to create an effective teaching force including developing a component of the course that focuses on the mathematics of children's thinking, incorporating technology into the course which will encourage discussion and promote discovery learning in geometry, and conducting a professional development workshop for new instructors of the courses to help them foster learner-centered environments which will enhance the class dynamic and increase student learning.

Funding Category

Indicate a primary (P) and, if applicable, secondary (S) funding category:

Professional Development S Program or Course Development/Modification P
LCE Research S Improved Assessment of Learning Outcomes

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PROPOSAL NARRATIVE

Abstract

Educating prospective teachers is an important component of creating an effective teaching force. We propose three strategies to enhance the mathematics courses for elementary teachers at the University of Arizona in learner-centered ways: (1) develop a component of the course that focuses on the mathematics of children's thinking, (2) incorporate technology into the course which will encourage discussion and promote discovery learning in geometry, (3) conduct a professional development workshop for new instructors of the courses to help them foster learner-centered environments which will enhance the class dynamic and increase student learning. A research component is included as well to examine student learning and teacher development.

Identification of need

It is now widely recognized that many teachers do not have the necessary conceptual understanding of the content that they teach, even at the elementary grades (Kilpatrick, Swafford, and Findell, 2001; Ma, 1999). In light of this, mathematics departments who are responsible for the mathematical preparation of future teachers must pay special attention to the content and instruction of the courses that these students take (Conference Board of the Mathematical Sciences, 2001). 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 prior to their methods and practicum experiences. The Mathematics Department offers six sections of each course per semester and enrolls approximately 600 students¹ per year. The purpose of these courses is to broaden prospective teachers' understanding of the common processes in elementary mathematics: place value, whole number operation, rational numbers and algebraic reasoning in MATH 302A; geometry, measurement, and data analysis in MATH 302B. As these courses relate directly to the material they will be teaching and impact such a large number of students, it is vital that they be designed to have the most positive impact on the students' future teaching career.

In many regards, these courses are already learner-centered. Both courses have traditionally emphasized collaborative learning and hands-on experiences where the focus of instruction is on developing understanding rather than memorizing rules and procedures. At the same time, we observe that there is still much room for improvement. At the center of this proposal is the development of new materials that better integrate aspects of children's thinking and technology into the course. In support of the creation of these materials, we also propose to create and implement professional development opportunities for instructors of this course. We will also engage in a research component that looks at the influences of the first two elements of the proposal on teaching and learning in Math 302A/B. In the following sections we will identify the needs for each of the three portions of the proposed project as well as explain how these parts support the Learner-Centered Education initiative.

Development of course materials

The main component of the project involves developing a series of learner-centered lessons for each of the two courses. The lessons developed in each course will follow a specific theme. For MATH 302A, we will design activities that work to intertwine mathematical and pedagogical ideas. Students will be given the opportunity to explore, interpret, and discuss children's thinking through written and video example of students' work. For MATH 302B, our focus will be on integrating technology. Specifically, we will examine the potential of *The Geometer's Sketchpad*² (Jackiw, 2001), a geometric construction/analysis program used widely in K-12 classrooms, to enhance MATH 302B students' learning of fundamental geometry concepts. Sketchpad lessons will be developed that emphasize exploration and discovery. All the lessons that will be developed will emphasize student engagement rather than teacher directed lectures. We intend to design three or four lessons for each course, where a single lesson could possibly span across several class periods.

The mathematical topics that the students engage with in MATH 302A are largely ideas that they have familiarity with, but have not thought deeply about or have a great deal of conceptual understanding

¹ Throughout this document, we will reserve the terms "students" for students in MATH 302A/B, "instructors" for instructors of MATH 302A/B, "teachers" for primary grade teachers, and "children" for primary grade students.

² Hereafter referred to only as "Sketchpad".

of (e.g. the meaning of dividing fractions, or the conceptual ideas behind the division algorithm used in schools). Moreover, many of these students do not believe there is more to know about elementary mathematics. We believe that children's thinking can be used as a vehicle through which these students can learn to appreciate and learn about mathematics. Using children's thinking as a means to examine mathematics is founded on the idea that teachers make use of much more than just content knowledge in their teaching practice (Ball, Lubienski & Mewborn, 2001; Shulman, 1987). In order for teachers to make their mathematical knowledge useable in a classroom, teachers must also develop sensibilities about how mathematical ideas develop in learners. At the same time, in order to analyze a learner's thinking for conceptual ideas, one must already have an understanding of these conceptual ideas. From this perspective, we see the process of examining children's mathematical thinking is fundamentally a mathematical task that is rooted in a context that is meaningful for teaching. It should be noted that neither MATH 302A nor MATH 302B are methods courses. While we advocate integrating pedagogical activities in the content course, the focus should properly be on mathematics content. In other words, rather than investigating instructional methods, we propose that students in MATH 302A investigate children's thinking for the purpose of identifying the children's mathematical understandings and thus bolstering their own understandings.

We will develop lessons where students can investigate children's thinking through written cases and video examples. Mathematical ideas that stem from these discussions can then be further investigated. It is important to note that the lessons about children's thinking will be learner-centered rather than teacher-centered. In groups and as a class, students will be given opportunities to present, debate, and refine their analyses of children's thinking.

In MATH 302B, the primary topic of study is geometry. Visualization and investigation are hallmarks of geometric reasoning, for which technology can be used as an effective tool. Learning in Sketchpad is supported by virtue of its dynamic, open design. Students can actively construct geometric objects and modify parameters to test conjectures. The lessons will be designed so that students can work in pairs or small groups to investigate complex, non-routine problems. These investigations would be followed by whole-class discussions during which mathematical ideas would be further developed. As with MATH 302A, the whole class discussions would be learner, not teacher, centered. During these discussions, ideas, solutions, and questions developed through pair or small group work would be taken up, examined, and debated by the class as a whole.

Professional Development

Until recently, the mathematics department only offered one content course for elementary teachers, MATH 301. It was decided that there was too much material to cover in the span of only one semester course, so movement progressed to split this course into two separate courses, namely MATH 302A and MATH 302B. While this provides the opportunity for instructors to spend more time on key mathematical concepts, it also creates a significant problem in terms of course staffing. As a single course, MATH 301 was typically staffed by mathematics education faculty or members of the department with special interests in education. With twice the number of courses to staff, this will now be impossible. Many instructors will likely have insufficient knowledge of critical factors of elementary school teaching. Moreover, these instructors will also probably not have had much experience with learner-centered education. New instructors of the courses will need to be trained in both these aspects.

An important component of our proposal is a three day workshop in August for instructors of the course to help them think about the structure and goals of the course. This workshop will be required for all instructors of MATH 302A/B. We have identified three areas of need that the workshop will address. First, the workshop will serve to familiarize instructors with the nature of elementary school mathematics. We intend to invite two teachers from area elementary schools, as well as Mathematics Education faculty, to help facilitate discussions and provide insights into the realities of the elementary classroom. Second, we will use the workshop to model learner-centered instructional techniques, such as collaborative work and hands-on use of manipulatives. Finally, the instructors will need to be introduced to specific lessons that pertain to examining children's thinking and using technology. We will familiarize the participants to research on children's thinking and to the Sketchpad computer environment. These lessons will have been already integrated into the course syllabus, allowing for the focus of the workshop to stay on implementing the lesson rather than on integrating lessons into an already existing syllabus.

Prior to the workshop in August a meeting will be scheduled in May for MATH 302A/B instructors. At this meeting we will distribute the course syllabus with new lessons integrated as well as

give them materials and outlines of these additional lessons. Meetings will also be scheduled through the semester to support the teachers in integrating the new lessons.

Research

Lesson development is best thought of as a cycle rather than a one time implementation. Examining the ways in which students' mathematical knowledge do or do not develop as they work through the proposed lessons will be necessary to help us identify areas in the lessons that may require modification. Our research will be guided primarily by qualitative research methodologies. Data sources would include students' written analyses of the children's mathematical thinking (for MATH 302A), computer-generated and written work related to Sketchpad lessons (for MATH 302B), video/audio tape of students working, video/audio of whole class instruction and interviews with a subset of the MATH 302A/B population. These data will allow us to generate a rich description of how learning is developing through the lessons. In addition to these qualitative methods, we also see the need to develop quantitative instruments to assess the extent of student learning and examine possible connections between the lesson implementation and student learning.

Technical Needs

Our primary technical needs derive from the planned implementation of Sketchpad lessons in the course and in the professional development workshop. We will have access to a computer lab with Sketchpad installed on each machine for use during one day of the workshop and through lesson implementation in Fall 2004. We will also have access in the classroom to a VCR and television for students to analyze examples of children's work. Finally, for our research the investigators will have access to video and audio recorders for data collection. We will require the services of a transcriber to assist in the analysis of these data.

Work Plan

Spring 2004

During this time we will begin to examine curricular materials and scholarly writings to shape the design of the lessons. Dr. Wiles will lead the design of materials for MATH 302A related to children's thinking. During Spring 2004 we will collect video resources to find segments that touch on key mathematical ideas. We will also create lessons, activities, and discussion questions to support the video segments chosen. Dr. McGraw will lead the design of materials for MATH 302B related to Sketchpad. In Spring 2004, we will review Sketchpad activities and begin to identify specific content areas of geometry to focus on. We will complete the outlines of these lesson plans by May 2004. Dr. Jayawant will lead the development and coordination of professional development materials. In Spring 2004, we will begin to integrate lesson outlines into the course syllabi. At a May meeting, we will distribute a clear articulation of the course syllabi and outlines of new lessons to 302A/B instructors. We will also begin to develop and coordinate workshop material for the August workshop.

Summer 2004

During this time lesson development will continue and be completed by August 2004. In addition, we will design instruments that can be used to assess student's understanding of key content of the lessons. The development of workshop materials will also continue in preparation for the three-day workshop in August. Implementation of the workshop will be coordinated by all three key personnel as well as Dr. Marta Civil, a Professor with ten years experience teaching the mathematics for elementary teachers courses. Dr. Jayawant will lead discussions about learner-centered instructional techniques. Dr. Wiles and Dr. McGraw will familiarize the instructors with the lessons that have been developed and lead the instructors in related activities. In addition, we will contract two area teachers to assist in facilitating during the workshop.

Fall 2004

Instructors of MATH 302A/B will begin implementation of the designed lessons in Fall 2004. Pre- and post-test data will be gathered from 302A/B students using the instruments developed to assess students' understanding of key lesson content. Qualitative data collection will also occur during Fall 2004. While data is being collected, we will engage in preliminary data analysis. Project personnel will meet to observe, discuss and refine their thinking about the data. Key themes will be identified and tested through the data.

Spring 2005

Qualitative data analysis will continue which will inform lesson modification and refinement. We will also begin analysis of pre- and post-test measures of students' understandings of key lesson content. At this time we can begin to disseminate initial findings internally through departmental, college, or university-wide colloquia. During Spring 2005, submission for conference presentations and planning for journal submission will begin.

The following chart contains our timeline and identifies key tasks and objectives for the project.

Timeline

Spring 2004	Summer 2004	Fall 2004	Spring 2005
<ul style="list-style-type: none"> • Activities resource collection • Lesson development • Meeting with 302A/B instructors to distribute lesson outlines (May) • Approval of research from human subjects committee 	<ul style="list-style-type: none"> • Lesson development continues • Development of materials for professional development workshop • Professional development workshop (August) • Construction of measures to assess student learning of key lesson concepts 	<ul style="list-style-type: none"> • Lesson implementation • Data collection continues (video/audio tape of instruction, collection of classroom artifacts such as student work, administration of assessment measures to MATH 302A/B students) • Transcription of data and data analysis begin 	<ul style="list-style-type: none"> • Lesson modification and refinement • Remaining transcription of data is completed • Data analysis continues • Dissemination of initial findings • Submission process for conference presentations of findings begins • Planning for journal submissions begins

Key Personnel

Key personnel for this project, including contact information, are as follows:

- Peter Wiles, Ph.D., Assistant Professor, 520-621-2389, wiles@math.arizona.edu.
- Rebecca McGraw, Ph.D., Assistant Professor, 520-621-6884, mcgraw@math.arizona.edu
- Pallavi Jayawant, Ph.D., Teaching Postdoctoral Fellow, 520-621-6870, jayawant@math.arizona.edu

Expected Results and Outcomes

We can identify several expected outcomes from this project:

- Preservice elementary teachers in MATH 302A will benefit from their ability to analyze and identify mathematical ideas in children's thinking.
- Preservice elementary teachers in MATH 302B will benefit from their ability to utilize computer software to investigate mathematical relationships.
- Working with elementary teachers and learning about children's thinking will give university instructors a better sense of how the material they are teaching will impact prospective teachers' in their future careers.
- Instructors of MATH 302A/B will benefit from becoming familiar with using computer software to create learning environments.
- Innovative lessons will be created and refined which can be used not only by future teachers of MATH 302A/B but also disseminated to other instructors of elementary education content courses.
- Rich descriptions of the process of how learning develops in novel instructional environments will inform current theories on teacher education and professional development.

The multiple data sources that will be gathered will provide ample opportunities to assess the effectiveness of the project. Pre- and post- test measures of student learning will provide one picture of how successfully the lesson was implemented in the classroom. We will also document student learning through the collection of student work and regular course assessments (e.g., quizzes and tests), and also as part of the Spring 2005 data analysis process (e.g., analysis of videotapes of class discussions). These data, as well as instructor feedback, will also serve to influence further modification and refinement of the lessons.

We anticipate that results from this project can be disseminated in several directions. Internally, the developed lessons will form a groundwork for future work on MATH 302A/B and serve as a model of learner centered education for other courses. Externally, the lessons that have been developed would be of great interest to teacher educators and can be presented at conferences such as that of the Association of Mathematics Teacher Educators. Research findings will also be of interest to organizations devoted to educational research (such as the American Educational Research Association) and research journals (such as the Journal for Mathematics Teacher Educators).

References

Ball, D. L., Lubienski, S. T., & Mewborn, D. S. (2001). Research on teaching mathematics: the unsolved problem of teachers' mathematical knowledge. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed.; pp. 433-456). Washington, DC: American Educational Research Association

Conference Board of the Mathematical Sciences (2001). *The Mathematical Education of Teachers: Part II*. Washington, DC: Mathematical Association of America.

Jackiw, N. (2001). *The Geometer's Sketchpad (Version 4.0)* [Computer software]. Berkeley, CA: Key Curriculum Press.

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding it up: Helping children learn mathematics*. Washington, D.C.: National Academy Press.

Ma, L. (1999). *Knowing ad teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Erlbaum.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57, 1-22.