IPESL Grant Application

(Initiative to Promote Excellence in Student Learning)
Minnesota State University, Mankato

PROPOSAL COVER PAGE

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Title of Project: **Thinking Critically about Algorithms**

Name: **Christopher Danielson**

Are you full-time faculty in 2006-2007? **Yes**
(fixed-term faculty are not eligible to apply)

Do you plan to return to MSU in 2007-2008? **Yes**

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Campus Phone: **507-389-6401**

College: **College of Science, Engineering and Technology**

Department: **Mathematics and Statistics**

Spring Semester Schedule:
List times when available to participate in Learning Communities and workshops.

Mondays:_____

Tuesdays: **3:00-5:00**

Wednesdays: **9:00-4:00**

Thursdays: **3:00-5:00**

Fridays: **9:00-4:00**

Christopher Danielson
Signature of Applicant

Larry M Pearson
Signature of Department Chair/Director/Supervisor

Signature of College Dean/Vice President

Thinking Critically about Algorithms

Purpose of project

Elementary licensure students take two required mathematics courses in the math department: Math 201 and 202, titled *Elements of Mathematics I* and *II*. A growing field of research supports the need for these courses. Hill, Schilling and Ball (2004) have asserted that a simple call for *more mathematics* is not the ideal solution for teacher licensure candidates because there is specialized knowledge of mathematics that teachers need to do their jobs effectively, called *knowledge of mathematics for teaching* (KMT) (see also Shulman's (1986) *pedagogical content knowledge* and Ma's (1999) *profound understanding of fundamental mathematics*.)

Need

The research cited above argues that teachers need to understand mathematics well enough to evaluate student responses and to choose representations that will help children learn. At present, the Math 201/202 sequence uses a textbook (Billstein, et al, 2003) that is scarcely influenced by this research.

Project goal

My project focuses on Math 201, in which whole-number and fraction computation algorithms are major foci. My project goal is for students to think critically about these algorithms.

Critical thinking

By *thinking critically about algorithms*, I mean analyzing student work by answering three questions:

1. What is the student doing?

2. Would this work on a different problem? and
3. Why does this algorithm work or not work in general? (i.e. what representation (e.g. diagrams, counterexamples, etc.) would make the algorithm, or its shortcomings transparent?)

Uncritical thinking, by contrast. is applied when students are asked only if an answer is correct, or to name an error pattern.

Project description and how it enhances critical thinking

This project will develop, implement and assess a new curricular approach to instruction in whole-number and fraction algorithms in Math 201. The approach focuses on building connected meaning for these algorithms and is influenced by Lesh, Post and Behr's (1987) model for mathematical understanding, which involves translating mathematical ideas among four representations: *symbols*, *words*, *pictures* and *physical models*. At present, Math 201 students as a group have acceptable skills in working with symbols but they lack knowledge of how symbolic algorithms can be represented and justified with words, pictures and physical models. This project will have two major activities:

1. research on effective representations for whole-number and fraction algorithms in curriculum development, and
2. implementation of materials to include these representations in instructional sequences in Math 201.

Research

The Third International Math and Science Study (TIMSS) has suggested that the elementary curricula of top performing nations, such as China and Singapore, include careful attention to the pictures and physical models presented to students. I will travel to the University

of Chicago's International Mathematics Education Resource Center to study the use of representations in these curricula.

Design and implementation

I will design and implement instructional sequences (units) to introduce Math 201 students to meaningful representations in domestic and international curricula and assignments to give them practice using these representations to analyze (i.e. to think critically about) novel symbolic algorithms. Because my work involves a research component, full implementation of these materials will not take place until the fall semester of the 2007—2008 academic year.

Assessment

The development of materials in this project will be under way during the spring semester, so assessment will be formative. I will administer items developed for another project as pre-tests and post-tests. I will need to reconstruct forms containing these items and to balance these new forms for content and difficulty.

These forms will generate a direct measure of students' growth in critical thinking about algorithms. One item asks teachers to evaluate a novel fraction comparison algorithm and assesses all three aspects of critical thinking in my definition above. Another item has teachers choose a diagram for representing a multiplication problem while justifying that choice, which assesses item 3 in the definition of critical thinking. The items are scored according to a scheme adapted from Flores (2006) for characterizing mathematical arguments (i.e. the degree to which mathematically critical thinking is applied). The items are also scored for correctness.

Dissemination

I will apply to speak at the Minnesota Council of Teachers of Mathematics meeting in Duluth, MN in March, 2007 and at the National Council of Teachers of Mathematics Regional Conference in Kansas City in October, 2007. This project should lead to future research on teacher learning. I plan also to write for publication for an audience of teacher educators.

This project will impact future versions of Math 201 and will better prepare students for Math 202, the Praxis exam and for teaching mathematics. It will produce materials for use in Math 483 and in professional development with practicing teachers.

University and department goals

This project supports a number of university, college and department goals including strengthening and focusing the preparation of students (here licensure candidates) for their careers through research-based programs and establishing a state-of-the-art program through the incorporation of international and current research-based domestic educational perspectives.

References

Billstein, R., Libeskind, S. & Lott, J. W. (2003). *A problem solving approach to mathematics for elementary school teachers.* Boston: Addison-Wesley.

Flores, A. (2006). How do students know what they learn in middle school mathematics is true? *School science and mathematics, 106*, (3), 124—132.

Hill, H. H., Schilling, S. G. & Ball, D. L. (2004). Developing measures of teachers' mathematical knowledge for teaching. *Elementary school journal, 105*, (1), 11—30.

Lesh, R., Post, T., & Behr, M. (1987). Representations and translations among representations in mathematics learning and problem solving. In C. Janvier, (Ed.), *Problems of representations in the teaching and learning of mathematics* (pp. 33-40). Hillsdale, NJ: Erlbaum.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher, (15)*, 2, 4—14.

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