Determining the Impact of Applet-Based Instructional Materials on Teacher Knowledge of Content and Pedagogy, Instructional Planning, and Student Learning of Fractions

Report of Preliminary Research Findings

Karen Wetherill
Carol Midgett
Marguerite McCall

Watson School of Education
University of North Carolina at Wilmington
Wilmington, North Carolina

This paper describes the preliminary findings of the first phase of a two-part study on the impact of NCTM E-Standards and Illuminations applets and support materials on teacher knowledge of mathematics content and pedagogy, instructional planning, and students' learning of fractions. This qualitative study is designed to describe how teacher's knowledge and practice changes as a result of using the "Fraction Track" applet as an instructional tool and document examples of student learning. Early findings from phase one indicate that teachers learn the "big mathematical ideas" that are foundational to concept development for students' understanding of fractions. The middle grades students were motivated to learn and saw new relationships with these electronic representations. Also, results indicate an increase in teachers' understanding of the relationship of pre-requisite knowledge about part-whole relationships and their ability to teach the addition and subtraction of fractions.

The second phase will continue studying the subjects in the first phase to collect formative data on the design of the applet-based resources and to engage the subjects in creating resources for the Illuminations website. In addition, phase two of the study will document the value of applets for upper elementary teachers and students and determine the impact of such on-line resources on improving instructional knowledge of lateral entry teachers, who are entering the profession with mathematical content knowledge applied in a context other than teaching. These findings will inform the selection of mathematical topics, the types of instructional resources that most effectively promote mathematical understanding, and strongly influence the development of applets that provide professional support for teachers with varying levels of experience.

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Context

The National Council of Teachers of Mathematics (NCTM) and the MarcoPolo Education Foundation have joined in a collaborative effort called the MarcoPolo Internet Content for the Classroom program. Eight professional organizations join NCTM in this consortium, each responsible for developing a standards-based educational website. The NCTM website, Illuminations, is designed to illuminate NCTM's *Principles and Standards for School Mathematics* (NCTM, 2000). A detailed discussion of the Illuminations project is available elsewhere (e.g. Hart & Keller, 2001; Keller, Hart & Martin, 2001).

As part of the outreach and content development efforts of the Illuminations project, Illuminations staff has helped provide professional development for middle grades teachers participating in an Eisenhower Grant at the University of North Carolina at Wilmington (UNCW). UNCW, a member of the University of North Carolina state-wide system, has close partnerships with ten public school districts in southeastern North Carolina. In 1993, a Professional Development System (formal university-school partnership) was created to establish a network among the Watson School of Education and surrounding public school districts to build a systemic approach to school improvement, teacher development and student achievement. The Watson School's conceptual framework is based on reflective practice and decision making, and is integral to the collaborative partnership. Our faculty, public school administrators, and teachers routinely dialogue to examine the reciprocal impact of our actions and activities for improving teaching and learning for both entities. The current focus is on developing best practices that increase student achievement.

Preliminary Findings for Phase I Research

The middle grades mathematics project "Leadership in Middle Grades Mathematics: Linking Effective Instruction to Student Learning" is a specific collaborative initiative of the Watson School of Education and area school systems. Based upon the vision set forth in NCTM's *Principles and Standards for School Mathematics* (NCTM, 2000), this project purposes to build teacher capacity including knowledge of mathematics, assessment of learning, leadership among colleagues, and integration of technology. During the summer of 2001, Eric Hart, Tom Gorski, and Carol Midgett, members of the Illuminations Development Team, provided professional development for thirty participants. The school teachers and university instructional team recognized the potential of Illuminations and E-Standards applets and support resources for developing mathematical content knowledge, for improving the design and delivery of lessons, and for increasing student interest and achievement in mathematics. This was made clear when a thirty-year veteran teacher exclaimed, while using the fraction applet, "the big mathematical idea is not the addition and subtraction of fractions but an understanding of proportional reasoning."

Based upon the success of the Illuminations-based professional development with these middle school teachers, the present research project was launched. The purpose of the research is to examine the impact of Illuminations and E-Standards on-line applet-based resources on:

- Teacher knowledge, content and pedagogy
- Instructional planning
- Teacher leadership with colleagues
- Student learning of addition and subtraction of fractions

From among the thirty summer participants, three teachers, with varying years of experience in teaching, were identified as subjects for this research. These teachers had openly spoken of the value of the applets as tools for helping students understand fraction concepts and demonstrated commitment to utilizing these tools in their classrooms.

The "Fraction Track" applet was selected because it demonstrates concepts that often pose problems for students and create instructional challenges for teachers. This interactive learning tool was one of the original electronic examples included in the *Principles and Standards for School Mathematics* (NCTM, 2000). The applet enables students to see relationships among different fractions as they make combinations that equal the whole. Students receive immediate feedback from the applet without negative consequences. Teachers can observe students using strategies for adding and subtracting fractions, ask questions that explore the thinking of students, and assess levels of understanding as students engage in using the "Fraction Track Game" (http://standards.nctm.org/document/eexamples/chap5/5.1/).

The specific questions addressed in this study are: (1) What is the impact of the "Fraction Track" applet as a professional development tool? (2) How does the fraction applet influence teacher's decisions about mathematics content and instructional strategies? (3) To what extent does the applet contribute to student's learning of mathematical content?

The initial observation focused on question 2, that is, the impact of this applet on teachers' decisions about what mathematical content to teach, how to convey that content, and methods of engaging students in learning the mathematics. The teachers' previous lessons on fractions were reviewed to determine strategies teachers generally used in teaching these concepts. The teachers completed pre- and post Concerns Based Adoption Model Inventory (CBAM) to determine their level of concern for the mathematical content, the relationship of the lesson design to the mathematics content, and determining student understanding. This diagnostic tool was used to track level of change and stages of concern, over time, experienced by teachers involved with implementing innovative classroom practice. The following elements of the lesson were studied:

- mathematical content
- instructional design
- instructional presentation
- methods of engaging students
- methods for assessing student learning

Data collected included videotaped lessons, videotaped interviews with the teachers, and teachers' written reflections. Being able to see the teaching in progress allowed teachers to observe themselves and reflect on their questioning strategies, decisions, actions, reactions, and remedial instruction. Interviews provided opportunity for the teacher's to think about their thinking in the process of teaching and reflect upon the impact of decisions on students thinking and learning.

When a paired t-test was used with the thirty participating teachers, it showed significant growth in teachers' ability to explain concepts. All teachers (100%) could describe how using open-ended questions, observations, and multiple representations of mathematical ideas could help analyze student learning from data collected and generate next-step plans based upon these findings. Two of the three teachers' involved in this study made the following comments that indicate changes they experienced:

> Teacher #1 stated, "I've never taught fractions to the whole before. I've really never thought about it. When I played this (game) at home I realized that. We've always compared fractions to each other and not related them to a whole."
> Teacher #3 shared, "Next time I use this game, I will stress more of the computational aspect of the game, that is, how to add parts to get to a certain number. I think my students were still weak in this area, especially since some were resorting to guessing at the end of the game. Paired with manipulatives and practice in computing with fractions, Fraction Track will be a very useful tool in my students' conceptual understanding of fractions in the future."

Follow-up data is being collected to examine the impact of the use of the fraction applet for extending students' mathematical understandings and clarifying their misconceptions. Although more comprehensive student data is forthcoming, preliminary pre and post assessments, from a sampling of students' representing a range of academic achievement's, have

been analyzed. These data revealed that each students' scores show at least 20% improvement and up to 50%.

All three teachers used the applet-based resources with parents. The adults were able to see mathematical relationships and expressed appreciation for the free access to these resources at home. Each teacher plans to conduct Parent Nights early in the upcoming school term to acquaint parents with Illuminations. The teachers expressed the belief that using these applet-resources will enable parents to better assist with mathematics homework assignments. This was an unanticipated outcome that suggests that parents might learn from Illuminations resources and they might serve as a medium for meaningful at-home mathematics activities

The preliminary findings indicate that the fraction applet gave teachers new insight into their own knowledge and their students' understanding or lack of understanding of the relationships among fractions. It confirmed that without modeling with multiple tools, students have a limited understanding of the relationships among fractions. Teachers learned from their observations and assessments that more time must be devoted to teaching equivalency and part-whole relationships to provide students a genuine understanding of what the algorithms represent. Data indicate that the fraction applet enables teachers and students to visualize mathematical relationships in ways that deepen their understanding of mathematics and how to use it, and use of the applet and supporting resources changes teachers' knowledge of student understanding and guides teachers to make changes in lesson design,

These data will be used by the Illuminations Project to inform the development of applets and supporting instructional material. They will be used by university faculty in course work and field experiences as instructional resources, for lesson design, and as a guide for reflecting

on instructional decisions. These data will inform the structure and design of professional development for in-service teachers aimed at adopting practices and resources that increase the achievement of K-12 students.

Future Plans for Phase II

One of the next questions to be investigated is the impact of the Illuminations applets and support materials on middle and high school teachers who are entering the profession with mathematical content knowledge applied in a context other than teaching (lateral entry). The study will follow these teachers through their initial year of teaching to measure the impact of the Illuminations resources on

- lesson design
- assessment of student learning
- understanding of instructional strategies that lead to increased student achievement.

In addition, the three middle grades teachers who were subjects of the original study will continue with the project allowing the researchers to examine the continued development and refinement of teachers's ownership and innovation. Finally, we will seek to determine the potential of Illuminations resources for developing and extending the mathematical understanding of upper elementary teachers and to measure the related achievement of their students when innovations are applied in their classroom.

This study is important because increased student learning is the purpose of teaching. Providing tools that develop knowledge, skills, and a context for application will provide professional growth experiences for mathematics teachers and make increased achievement available to more students.

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