

# Learning to Learn to Teach

## Implementing and Assessing an “Experiment” Model for the Continuous Improvement of Teaching

U of Delaware Mathematics Education Group  
AERA – April 15, 2004

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Foundation



## UD Work to be Described

- Developing a model for continuous research-based improvement --Laura Kincaid & Yuichi Handa
- Testing and refining the model
  - Changes in mathematical proficiency  
--Christine Gorowara & Diana Wearne
  - Can pre-service teachers treat lessons as experiments?  
--Anne Morris
  - New measures of teachers' ability to learn from teaching --Dawn Berk, Anne Morris, & Eric Sisofo

April 15, 2004



The purpose of this session is to provide an update of our work on creating and testing an “experiment” model of teacher preparation. As will become clear, the term “experiment” is not to be confused with “experimental.” It was chosen to emphasize the deliberate, systematic study of teaching aimed to build, over time, a knowledge base for teaching and for preparing teachers.

## An Enduring Problem

- Building a useful knowledge base for teaching and teacher education
  - Teachers start over rather than picking up from where their predecessors left off.
  - Teacher educators learn from each other only in haphazard ways.
  - No mechanism for generating, vetting, and representing knowledge to ensure incremental, steady, lasting improvement.

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One of the most significant problems in education is the absence of a knowledge base that allows teachers, and teacher educators, to build on what others have learned. Indicators of the absence of such a shared and usable knowledge base are well known.

A primary reason for this enduring problem is the absence of a mechanism for generating, vetting, and representing knowledge in a way that makes it available and useful for others.

Our response to this problem is the development of a model for the continuous improvement of teaching.

## An “Experiment” Model for the Continuous Improvement of Teaching

- Learning from *planned* experience
- Helping others learn from one’s own experiences
- Using the common everyday lesson as a unit for analysis and improvement
- Improving rather than reforming
  - Gradual, steady, cumulating improvement

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The model is based on a number of old but powerful ideas.

1. Everyone learns from experience everyday. Teachers learn from their routine experiences of teaching. But most of this learning is haphazard and fleeting. At the center of our model is the value of planning to learn in a systematic, deliberate way, especially planning to learn from teaching.
2. It is not good enough for teachers, or teacher educators, to become better skilled practitioners or to accumulate knowledge for their individual practice. Building a knowledge base means that every teacher is responsible to help others learn from each individual’s experience.
3. Because teachers teach by planning and delivering daily lessons, and because lessons are large enough units to contain the important interactions in the classroom but small enough to study intensively, we focus much of our work on studying and improving lessons. The outcomes include more general principles of teaching that span individual lessons.
4. Reforms have a way of contributing to pendulum swings buffeted by the latest fads; long-term steady, lasting improvement, even though incremental, has much greater payoff in the long run.

## Learning from Planned Experience: An Old Idea

“Men [sic] have always been capable of some mental processes of the kind we call ‘learning from experience.’ Doubtless this experience was often a very imperfect basis and the reasoning processes used in interpreting it were very insecure . . . Experimental observations are only experience carefully planned in advance, and designed to form a secure basis of new knowledge” (R. A. Fisher, *The design of experiments*, 1949, p. 8).

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The origins of the principles or assumptions of our model are difficult to trace, but the notion of learning from planned experience has a source that links directly to the concept of treating lessons as experiments.

## **“Experimental Observation” of the Everyday Experience of Teaching**

- The usual phases of teaching a lesson are slowed down and studied systematically
  - Planning
  - Implementing
  - Reflecting
- Lessons become “experiments”
  - They are the target for analysis and improvement.
  - They are a form in which knowledge for teaching becomes represented.

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Everyday, teachers engage in the familiar routine of planning lessons, implementing them, and reflecting on how well they worked. What if we could slow down these phases of teaching and think of them as contributing to conducting careful, intentional “experiments.”

## Treating Lessons as Experiments

- **Planning**
  - Setting learning goals for students
  - Constructing hypotheses about the effects of the instruction on students' learning
  - Planning to collect evidence on students' learning
- **Implementing**
  - Teaching the lesson
  - Collecting evidence on students' learning
- **Reflecting**
  - Analyzing the evidence in terms of learning goals and hypotheses
  - Making decisions to . . .
    - Improve the lesson
    - Improve the hypotheses

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The three phases of teaching could include much more than just planning a sequence of activities, implementing them with students, and making a few quick mental notes about which ones worked well. Unpacked as shown on this slide, it is possible to see how lessons could become experiments. Treating even a few lessons in this way would give teachers the chance to study teaching systematically.

The phase of teaching on which educators usually focus their attention is “implementing”—teaching the lesson. This is where the “rubber hits the road.” But this also is the phase that can depend on personality traits and extemporaneous decision-making. We are especially interested in planning and reflecting--phases in which all teachers, regardless of their “natural gifts,” can improve through study and hard work. In addition, it is these two phases that will produce significant aspects of a growing knowledge base for teaching.

## Plan for the Session

### Improving the Courses Using the Experiment Model

- Lesson Study Process  
Laura Kincaid
- Cycle of Revising  
Lessons and Testing  
Effects  
Yuichi Handa

### Evaluating Course Changes and Students' Thinking Using More Classical Research Designs

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  - Collecting evidence  
Anne Morris
  - Planning to collect evidence  
Dawn Berk
  - Learning from practice  
Eric Sisofo

### Comparing Models of Teacher Preparation

Deborah Ball, Hyman Bass, & Laurie Sleep, U of Michigan

April 15, 2004



We organized the session to highlight the fact that we are developing and testing the model by engaging in two kinds of research processes. The first is a modified version of lesson study in which instructors for each of the pre-service mathematics courses engage in semester long collaborations to implement and then improve the lessons for the course. The second includes more classic research designs that, at this point in our work, are focusing on the entry abilities of pre-service teachers to engage in the individual processes necessary for treating lessons as experiments.

## The Continuous Improvement of Teaching

- For teachers to become expert, they need to continue learning from their practice
- Not a new idea
  - “It may be possible to learn in two or three years the kind of practice which then leads to another twenty years of learning. Whether many of our colleges get many of their students on to that fascinating track . . . is another matter” (David Hawkins, “What it means to teach,” *Teachers College Record*, 1973, p. 7)

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One assumption in our model of continuous improvement is that we cannot develop pre-service teachers into expert teachers in four years. Rather, for teachers to become expert, they need to continue learning from their practice.

This desire to have teacher education programs develop life-long learners is another of the old ideas on which we are building (see quote).

## Learning Goals for Pre-Service Teachers

- Two requirements for continuous improvement
  - Learn how to learn from practice—how to treat lessons as experiments
  - Become mathematically proficient (NRC, 2001)

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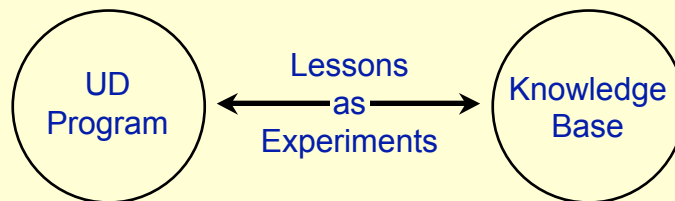
In the UD teacher education program, there are two learning goals for pre-service teachers. These express our fundamental values. We believe they are required to continually improve one's teaching.

The second goal of mathematical proficiency is included because skills to learn from one's practice are not enough.

This set of goals applies to two groups of people in our program: pre-service teachers and teacher educators.

## Using the “Experiment” Model to Improve Courses

- Teacher educators study lessons in content and methods courses
- Vehicle for the program and knowledge base to inform each other



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Our teacher educators have the opportunity to treat lessons as experiments when teaching mathematics content and methods courses for pre-service teachers. By doing so, lessons as experiments become a vehicle for the program and knowledge base to inform each other.

For example, a group of instructors for a particular course create a set of lessons (refer to the “UD program” circle). Then, they study these lessons by collecting data during the enactment of the lesson and analyzing it (refer to the “Lesson as Experiment” arrows). Finally, these data and the revised lessons based on the data contribute to the knowledge base on Teacher Education (refer to the “Knowledge Base” circle). These revised lessons now become the object of study for the next semester and the cycle continues. This feedback cycle allows for the gradual improvement of lessons over time.

## Overview of the UD Program

- 3 content courses and 1 methods course
- 3 to 7 sections of each course a semester
- 1 Faculty Coordinator per course

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In the UD program, pre-service teachers take three mathematics content and one mathematics methods course. Most students begin this 4-course sequence their freshman year.

There is one faculty coordinator per course, and the other instructors are primarily doctoral students.

## Implementation of Lesson as Experiment

- Timeline for the four courses

	S02	F02	S03	F03	S04	F04
Content 1						
Content 2						
Content 3						
Methods						

- Weekly meetings to discuss lessons

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The treatment of lesson as experiment has been introduced, in sequence, across the four courses. The first content course adopted this model of continuous improvement in the Spring of 2002, and the methods course will implement this model this upcoming Fall semester.

When a course adopts this model to improve the course, the instructors meet weekly for 1-2 hours to discuss how they will study the lessons.

## Informal Collection of Data

- At some weekly meetings, discuss:
  - Self-reported evidence of the effectiveness of activities
  - Unanticipated student responses
  - Suggested changes to the lesson plan

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At some weekly meetings, the discussion centers around data that have been informally gathered. These data include instructors' impressions from teaching the same set of lessons, cross-class observations by the instructors, and feedback from students through usual class assessments.

## Systematic Collection of Data

- At other weekly meetings, discuss:
  - Research questions around the lesson
  - Observations from the enacted lesson
  - Coding and analysis of data
  - Revision of research questions
  - Suggested changes to the lesson plan

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Sometimes the collection of data is more formal.

The changes made to the lesson contain the knowledge gained through sharing information among instructors—these changes include notes for future instructors on key aspects of the lesson, anticipated pre-service teachers' responses to lesson tasks, and hypotheses regarding the learning benefits for particular activities that should be studied and revised the following semester.

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## A cursory narrative of 'lessons as experiments' among teacher educators

- **Content Course 2:** Rational number concepts (fractions, decimals, percents, proportional reasoning, probability)
- **Each semester:** 4 to 6 instructors

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The second math content course in the 3-semester sequence focuses on rational numbers.

## Fall 2002 and Spring 2003

- **Primary Focus:** Building of a lesson-by-lesson curriculum
- **Purpose:** To have a satisfactory starting place to begin the process of making small improvements each semester
  - Weekly 2-hour meetings
  - Preview and Debriefing: What worked, what did not
  - Some informal observations
  - Some issues are tabled for later discussion.

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We began the course improvement process by developing a full set of daily lessons. We found this was necessary for studying teaching at the detailed level that we believe is essential for generating useful knowledge for teaching.

## Summer 2003

- Selected proportional reasoning lessons as the site for intensive study and improvement
- Reasons:
  1. Concern about the lessons: Issue of 'difference' (Yackel & Cobb, 1996) of solution strategies for pre-service teachers
  2. Little knowledge of abilities of pre-service teachers
  3. Difficulties for pre-service teachers
  4. Mathematical importance

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Once a curriculum was in place, we could begin studying a few lessons more intensively.

## Fall 2003

- **Planning:** Planning to collect evidence on pre-service teachers' in-coming abilities and learning
  - What can they do prior to instruction?
- **Collecting:** Informal observations, self-reports, student work
- **Analyzing:** Debriefing sessions; many observations, particularly of solution strategies
  - Our pre-service teachers can do more than we expected!
  - Some adapt their strategies depending upon the given proportion problem; others do not.
- **Making Decisions:** Set 2 new primary learning goals:
  1. Diversity/flexibility of solution strategies
  2. Efficiency of solution strategies

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This academic year, we have been studying proportional reasoning by applying the continuous improvement model to our own work as teacher educators. We are emphasizing those aspects of teaching that involve careful and deliberate planning and reflecting.

## Spring 2004 (in progress)

- **Planning:** Form research question around instructional approach; create alternative lessons
  - Pre-service teachers generating solutions
  - vs.
  - Pre-service teachers analyzing “children’s” (worked) solutions
    - **Question:** How will the use of strategies differ between the 2 groups of pre-service teachers when solving proportion problems?
- **Collect:** Pre- and post-tests, pre- and post-interviews, observations, self-reports, student work

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Currently, we are conducting a targeted research study on the effectiveness of several proportional reasoning lessons. We have developed two different approaches to teaching these lessons and are collecting evidence on what kinds of learnings result from each approach. We will use the data to revise the lessons for next semester, perhaps selecting the more effective approach, and we will revise our hypotheses regarding links between instructional activities and pre-service teachers’ learning.

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## Delaware Rational Numbers Concepts Assessment

- Designed to measure changes in the mathematical proficiency of pre-service teachers over time
  - Mathematical proficiency as defined in *Adding It Up* (National Research Council, 2001)

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The Lesson Study process summarized on the previous slides focuses on making and measuring local improvements in a single course. We also have a large-scale assessment that measures changes over time across all four of our mathematics courses.

## Description

- Written test
- 9 questions (23 sub-questions)
- Largest quantitative measure over time
- Rational number content

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There are several reasons that our assessment focuses on rational number content. First, the literature indicates that this is an area of difficulty for pre-service teachers. Second, the focus of the second content course is rational number concepts, and rational number concepts are a part of all four courses. Third, rational number concepts are important foundationally for more advanced mathematics, such as algebra.

## Two Types of Items

- Mathematical Proficiency
  - Solving number sentences and word problems
  - Writing stories for number sentences
- Mathematical Proficiency for Teaching
  - Predicting and explaining students' errors
  - Creating mathematics problems that support particular learning goals

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These items are presented in written form, many of them open-ended. Examples of these items, along with assessment results of those items, are given in later slides.

## Administration and Analysis

- Administration before course improvement process, Fall 2002
- Administration after course improvement process:
  - Track cohorts as they move through the program
- Analysis of changes:
  - Before to after course improvement
  - Cohort to cohort after improvement process

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All students in all four courses were given the assessment in Fall 2002, before the course improvement process began, in order to establish a performance baseline. Students in the cohort that began the course sequence in Fall 2002 (Cohort 1) and students in the cohort that began the course sequence in Spring 2003 (Cohort 2) have been assessed at the beginning of each semester.

## Sample Result

(Test administered at the beginning of the third course)

Solve the number sentence:

$$2\frac{3}{8} - \frac{2}{3} = \square$$

---

Baseline (Before Course Improvement):	76.5%
Cohort 1 (After Course Improvement):	78.9%
Cohort 2 (After Course Improvement):	71.4%

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This is an example of a straightforward item that requires pre-service teachers to solve a number sentence. The slide shows the percentage of students who responded correctly after completing the rational numbers content course. There is no statistical difference in the percentages responding correctly.

## Sample Result

(Test administered at the beginning of the third course)

Write a story in the space below that goes with the following number sentence:

$$2\frac{3}{8} - \frac{2}{3} = \square$$

---

Baseline (Before Course Improvement):	50.0%
Cohort 1 (After Course Improvement):	84.6% *
Cohort 2 (After Course Improvement):	91.3%

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This is an example of a item that requires pre-service teachers to write a story for a number sentence. Again, the pre-service teachers in each group were tested after completing the rational numbers content course. The difference between the Baseline and Cohort 1 is statistically significant at the 95% confidence level. The difference between Cohort 1 and Cohort 2 is not significant. It appears that the initial changes in the course positively affected pre-service teachers' learning of this skill but the later changes, which were less substantive, did not affect their learning.

## Sample Result

(Test administered at the beginning of the third course)

A store marks everything up 75% from the wholesale price. If the selling price is \$140, what was the wholesale price?

- Alan thought the wholesale price was \$65
- Ben thought the wholesale price was \$75
- Charlie thought the wholesale price was \$80
- David thought the wholesale price was \$105

Alan or David (or both) is incorrect. Describe how either Alan or David (select one) might have arrived at his incorrect solution.

---

Baseline (Before Course Improvement):	63.7%
Cohort 1 (After Course Improvement):	69.2%
Cohort 2 (After Course Improvement):	82.9% **

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This is an example of a item that requires pre-service teachers to explain student errors. Again, the pre-service teachers in each group were tested after completing the rational numbers content course. There is no difference between the Baseline and Cohort 1, but the difference between Cohort 1 and Cohort 2 is statistically significant at the 90% level of confidence. In this case, it appears that the second set of changes to the course had a greater influence on pre-service teachers' ability to explain student errors than the first set of changes. We plan to track changes in students' responses to similar items for the foreseeable future in order to understand the effects of course changes, even if minor.

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## Treating Lessons as Experiments

- **Planning**
  - Setting learning goals for students
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  - Planning to collect evidence on students' learning
- **Implementing**
  - Teaching the lesson
  - **Collecting evidence on students' learning**
- **Reflecting**
  - Analyzing the evidence in terms of learning goals and hypotheses
  - Making decisions to . . .
    - Improve the lesson
    - Improve the hypotheses

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This study focused on whether beginning pre-service teachers could engage in one of the processes that we believe is critical for treating lessons as experiments—collecting evidence on the effects of instruction on students' thinking.

A more complete report of this study is available from Anne Morris.

## Evaluating Lesson-as-Experiment Skills

Can pre-service teachers collect evidence about the effects of instruction on students' learning and thinking?

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Information about the extent and nature of pre-service teachers' entry abilities to study teaching is useful for designing instructional activities in the courses that help them develop these abilities. A first question is whether beginning pre-service teachers can collect evidence about the effects of instruction on students' learning.

## Research Question

What do pre-service teachers take as evidence for their hypotheses about the effects of instruction on students' learning?

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## Method

- 15 undergraduate pre-service elementary and middle school teachers
- All were enrolled in the first of the four courses in the mathematics teacher preparation program.
- Participants watched a videotape of a fifth grade lesson on the area of a rectangle and triangle.
- Participants were asked to form a hypothesis about what the children learned and understood by the end of the lesson, and to support their hypothesis with evidence.

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## Results

- There were particular types of deficiencies in the pre-service teachers' evidence-gathering:
  - Type 1: Referenced teacher only
  - Type 2: Focused on correctness rather than understanding
  - Type 3: Did not distinguish between hypotheses and evidence

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Only one aspect of the findings are presented here. Consult the full paper for a complete report of the results.

## Type 1: Referenced Teacher Only

- 40% of the pre-service teachers supported at least one hypothesis about students' learning with empirical evidence that referred only to the teacher's explanations.
  - “The children understand the concept behind square units. [My evidence for this is] the teacher introduces square units and starts giving examples on the board.”
  - “The children understand that the height and base are not always in the same places on a triangle. [My evidence is] because the teacher said that a triangle's height must always form a right angle with the base.”

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## Type 2: Focused on Correctness

- For one or more of the covered concepts, 87% of the pre-service teachers accepted student responses that provided little information about student understanding as evidence for understanding.
- The pre-service teachers appeared to focus on the correctness of a response rather than the connection between the content of the response and the understanding that it was supposed to show.

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## Type 2: Examples

- “The children understand that area is the amount of space in an object. [My evidence is] they were able to count up the squares in the teacher’s examples to see how many square units were in the rectangle.”
- “The children understand that they always need a right angle to have a base and height. [My evidence is] the children give the base and height [when the teacher asks for the base and height of a figure on the board where the height is drawn as a dotted line and the dimensions are indicated].”

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### Type 3: Did Not Distinguish Between Hypotheses and Evidence

In 40% of the pre-service teachers' responses, the evidence included more hypotheses.

"The children know that they have to use a different formula when solving for the area of a rectangle/square in comparison when solving for the area of a triangle. [My evidence is] the students knew that since [this] is a rectangle/square they would need to use the formula  $\text{Area} = l \times w$ . On the other hand, if the students were given [a triangle] the students knew since you can't count up the number of squares in a triangle (some are  $1/2$ ,  $1/4$  squares), they need to use another type of formula. When solving the area of a triangle they would use the formula  $\text{Area} = 1/2 \times b \times h$ . They knew that they had to use base  $\times$  height because they needed to use two numbers where the lines created a right angle."

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The underlined portion of this response is the only evidence provided; the rest of the comments are more hypotheses.

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A forthcoming study will build on the previous study by investigating the effects of asking pre-service teachers to plan to collect evidence before viewing a videotaped lesson. Will this analysis beforehand help pre-service teachers look for different kinds of evidence (e.g., will it help them learn different kinds of things from viewing a videotaped lesson)?

## Purpose of the Study

- Build on findings from study on supporting hypotheses with evidence
- Test out an important component of our model – Planning

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## Treating Lessons as Experiments

- **Planning**
  - Setting learning goals for students
  - Constructing hypotheses about the effects of the instruction on students' learning
  - **Planning to collect evidence on students' learning**
- **Implementing**
  - Teaching the lesson
  - Collecting evidence on students' learning
- **Reflecting**
  - Analyzing the evidence in terms of learning goals and hypotheses
  - Making decisions to . . .
    - Improve the lesson
    - Improve the hypotheses

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Planning to collect evidence is another component of the more complete model of teaching in which we are situating our work.

## Why investigate planning?

- Research suggests that planning matters  
(e.g., Gollwitzer 1996, 1999; Diefendorff & Lord, 2003)
- Planning might affect what pre-service teachers see in the classroom
- Planning might help pre-service teachers assume a more critical stance

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## Research Questions

- What kinds of evidence do pre-service teachers plan to collect, and what kinds of evidence do they actually collect?
- How does the process of planning to collect evidence...
  - Affect the nature and quality of the collected evidence?
  - Affect pre-service teachers' analysis of a lesson?
  - Affect pre-service teachers' teaching (specifically, their lesson planning)?

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## Participants

- 30 pre-service teachers enrolled in 2<sup>nd</sup> mathematics content course
  - Randomly selected
  - Randomly assigned to control group (n = 15) or treatment group (n = 15)
- 15 pre-service teachers enrolled in mathematics methods course
  - Randomly selected
  - Assigned to the treatment group

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## Method

### Both groups...

- Charged to assess the effectiveness of a math lesson

### Before viewing the videotape...

- Control group read the lesson plan
- Treatment group read the lesson plan and planned for what evidence to collect

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## Method, continued

Both groups then completed three tasks...

- Viewed videotaped lesson twice and collected evidence
- Used evidence to evaluate the effectiveness of the lesson
- Used evidence and analysis to make revisions to the lesson

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# Results

(Available Fall 2004)

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## Hypotheses

1. Our graduates will differ from “typical” teachers with respect to the following:

- **Planning**
  - Setting learning goals for students
  - Constructing hypotheses about the effects of the instruction on students’ learning
  - Planning to collect evidence on students’ learning
- **Implementing**
  - Teaching the lesson
  - Collecting evidence on students’ learning
- **Reflecting**
  - Analyzing the evidence in terms of the learning goals and the hypotheses
  - Making decisions to . . .
    - Improve the lesson
    - Improve the hypotheses

2. Our graduates will view their classroom as one of the most important sites where they can learn to improve their teaching.

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We have two primary hypotheses about how the graduates of our program will differ from non-graduates. First, our graduates will differ in the way they engage the usual phases of teaching:

- (1) How they plan to learn from teaching,
- (2) How they collect evidence from teaching,
- (3a) How they analyze evidence they have collected from teaching, and
- (3b) How they make decisions from their analyses of data in order to improve.

Second, our graduates will, to a greater extent than non-graduates, view their classroom as one of the most important sites where they can learn to improve their teaching.

## Research Questions

- RQ #1: What are teachers' ideas about what it means to "improve" their teaching, and in what ways do teachers try to improve?
- RQ #2: How do teachers learn from teaching (their own teaching or that of others) in order to improve?
  - A. How do teachers plan to learn from teaching?
  - B. How do teachers collect evidence from teaching?
  - C. How do teachers analyze evidence they have collected from teaching?
  - D. How do teachers make decisions from (their analyses of) data?
- RQ #3: What, if anything, do teachers learn from studying teaching?

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To test these hypotheses, we are conducting a study now on how non-graduates ("typical" practicing teachers) learn from their practice. We have three research questions, shown on this slide, to guide data collection. We will collect comparative data from a sample of graduates as soon as they enter the field.

## Methods: Collecting Baseline Data

- Extended interview with 3 components
  - General interview
  - Pre-observation interview
  - Post-observation interview
- Collect data on “typical” in-service teachers
  - Range of teaching experience
  - Range of grade levels (1 – 8)
- Later use same items with our graduates

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We are using an extended interview format that includes a general interview and a pre- post- interview around a specific lesson. Participants have a range of teaching experience and are teaching in a range of grade levels 1 - 8. We will use the same assessment items with our graduates when they begin teaching and then run the appropriate comparisons.

# Results

(Available Spring 2005)

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# Summary

- The UD mathematics education group is committed to developing and testing a continuous improvement model for teaching.
- This process provides a vehicle for learning how to build a knowledge base for teaching and teacher education.
- As the work proceeds, it is becoming apparent that we also are building a community that learns from its own experience—in a planned, intentional, and incremental way.

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