

*Teacher Efficacy among Pre-Service Middle School Mathematics Teachers:  
How Do They Evaluate Their Instructional Effectiveness?*

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Abstract

The purpose of this study is to document criteria used by pre-service middle school mathematics teachers when evaluating the effectiveness of their mathematics instruction. 33 pre-service teachers either participated in interviews or completed open-ended questionnaires about the effectiveness of their instruction when implementing a common lesson plan designed to help students understand the division of fractions algorithm. Results demonstrate that these pre-service teachers had a focus on student outcomes when evaluating their instruction, and they were more likely to critique features of the lesson than their teaching. Pre-service teachers who observed negative student outcomes were able to describe their students' thinking in a more nuanced manner, while pre-service teachers who observed at least some positive student outcomes were more likely to link their evaluations of their instruction with students' learning. Results of this study provide an empirical base to enhance theoretical discussions of alternative perspectives on teacher efficacy and insight on the development of middle school mathematics teachers' efficacy.

**\*\*\*DRAFT ONLY\*\***

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*Teacher Efficacy among Pre-Service Middle School Mathematics Teachers:*

*How Do They Evaluate Their Instructional Effectiveness?*

In mathematics methods courses, pre-service teachers teach mathematics lessons in their field placement classrooms, and the criteria they use to determine whether or not their instruction was effective has the potential to shape what they learn from their teaching experience as well as how they teach future lessons. The purpose of this study is to document the criteria used by pre-service middle school mathematics teachers to evaluate the effectiveness of their mathematics instruction during a lesson designed to help middle school students understand the meaning of the division of fractions algorithm. The results of this study provide an empirical base to enhance theoretical discussions of alternative perspectives on teacher efficacy as well as insight on the development of middle school mathematics teachers' efficacy.

*Analysis of Teaching Skills*

We designed this study to examine pre-service teachers' entry level abilities for analyzing and evaluating their own teaching. Previously, my colleagues and I articulated a framework for teacher education that aims to help pre-service teachers develop skills that help them learn from their own teaching (Hiebert, Morris, Berk, & Jansen, 2007). We consider the following skills to be useful for analyzing teaching in light of students' learning. First, teachers need to specify their learning goals for an instructional episode, or determine what their students are supposed to learn. Then, teachers conduct empirical observations of teaching and learning and determine what students learned. Next, teachers construct hypotheses about the effect of teaching on student learning to determine whether and how teaching helped (or not) students learn. Finally,

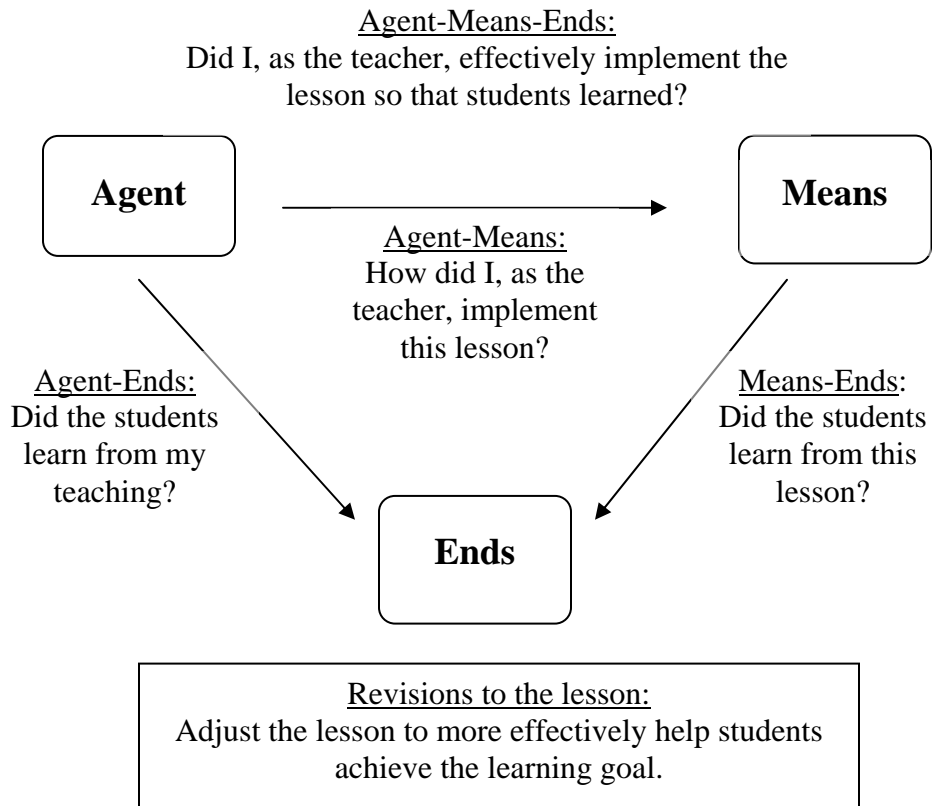
teachers use their analyses to propose improvements in teaching and revise their teaching to help students learn more effectively. Previous research has examined pre-service teachers' entry level skills when engaging in analysis of others' teaching (Morris, 2006). In this study, we examine pre-service teachers' entry level skills for evaluating their own instruction.

Based on the analysis of teaching skills described above, in a strong evaluation of teaching, a teacher links evaluative statements about instruction to students' learning outcomes. Additionally, in a strong evaluation of teaching, a teacher would describe what students' learned as specifically as possible, both with respect to the nature of their mathematical understandings and the relative amount of students within the class who exhibited those mathematical understandings. Finally, the revisions proposed by the teacher in a strong analysis of teaching would be targeted and aligned with the original learning goal set for the instructional episode.

### *Teacher Efficacy*

In addition to illustrating pre-service teachers' entry level skills for analyzing their own teaching, evaluations of their instruction indicate the nature of their teacher efficacy. Teacher efficacy refers to teachers' beliefs about their abilities to promote students' learning. For the purpose of this study, we take an interpretivist approach to the study of teacher efficacy in response to calls for examinations of teacher efficacy from alternative approaches and perspectives (Labone, 2004; Smith, 1996; Wheatley, 2005). Teacher efficacy is usually assessed by researchers with forced choice Likert-scale surveys, which do not consistently illuminate teaching processes in the classroom context related to efficacy. Interpretative methods have been suggested as an alternative (Labone, 2004).

Figure 1: Criteria for Evaluating Instruction



*Looking beyond agent-ends efficacy beliefs.* Wheatley (2005) describes Skinner's (1996) taxonomy of control beliefs related to efficacy beliefs as means-ends beliefs, agent-ends beliefs, and agent-means beliefs. Pre-service teachers' criteria for determining the effectiveness of a mathematics lesson is likely to reveal *means-ends* teacher efficacy beliefs, such as which teaching strategies or lesson features would help students achieve the learning goal of the lesson, *agent-ends* teacher efficacy beliefs, whether the teacher believes she is capable of teaching the students such that they achieve the learning goal, *agent-means* teacher efficacy beliefs, whether the teacher believes she is capable of enacting the teaching strategy, or *agent-means-ends* teacher efficacy beliefs, whether the teacher believes she can use teaching methods that effectively lead to student outcomes.

Researchers typically focus on agent-ends beliefs when studying teacher efficacy (e.g., Hoy & Spero, 2005), but this focus obscures which practices teachers enact and whether they believe they can or should enact teaching practices aligned with mathematics reforms. For example, if assessing an agent-ends teacher efficacy belief, such as “I can teach my students about division of fractions effectively,” it is not clear whether the teacher would enact a more lecture approach to achieve the desired end through modeling and direct instruction or whether the teacher would enact an approach to teaching mathematics designed to promote students’ autonomy for learning mathematics, such as exploratory learning and discussion in which students engage in mathematical reasoning and justification. If teacher educators are concerned with whether pre-service teachers believe particular teaching practices would be effective in their classroom or whether pre-service teachers believe they are capable of enacting these practices, then an examination of means-ends and agent-means efficacy teacher efficacy beliefs would be illuminating.

*Teacher efficacy beliefs of pre-service mathematics teachers.* Reforms in mathematics education have challenged the assumption that teachers can be direct causal agents in student learning (Smith, 1996), suggesting the importance of attending to means-ends and agent-means efficacy beliefs. Prior to reforms, teachers may have been more likely to believe that a teacher’s delivery of a clear explanation would result in students learning mathematics. Reforms ask teachers to help students make sense of mathematics on their own terms, and provide the potential for alternative opportunities for mathematics teachers to feel efficacious, including whether they can pose good questions or select provoking mathematics problems for their students. Newer teachers struggling to implement teaching practices different from how they

were taught may be trying out means to ends in which they lack confidence, experience, or belief in the effectiveness of the teaching practices.

Studying pre-service teachers' efficacy is challenging because they lack experiential basis for drawing links between their teaching and student learning (Smith, 1996), but it is important to study teacher efficacy among pre-service teachers, as Bandura's (1977) theory of self-efficacy suggests that efficacy is most malleable early in learning. Hoy and Spero (2005) found significant growth in teacher efficacy during student teaching and significant declines during the first year of teaching using Likert-scale surveys. They determined that the decline was related to a decrease in support after student teaching and an initial underestimation of the complexity of teaching. Romano (2004) conducted an interpretive self-study of "bumpy moments" experienced in her second year of teaching elementary school; as might be expected from a newer teacher, she observed that she usually attended to management issues.

Studies with pre-service mathematics teachers indicate that mathematics anxiety was negatively correlated with confidence to teach elementary school, while enjoyment with mathematics was positively correlated with confidence to teach (Brady & Browd, 2005). Additionally, Swars (2005) found that past experiences with mathematics were associated with mathematics teacher efficacy among pre-service elementary teachers. Current research focuses on whether or not pre-service mathematics teachers have high teacher efficacy and identifying factors associated with high teacher efficacy, but more research is needed among pre-service mathematics teachers to assess means-ends and agent-means beliefs.

A complexity with studying teacher efficacy among pre-service teachers is their potentially low degree of comfort with expressing doubts about their own efficacy in contrast, yet doubts have potential for promoting learning (Wheatley, 2002). Pre-service teachers

especially may feel a strong need to be certain about the effectiveness of their instruction, and this need for certainty may stifle openness to discussion and reflection. Additionally, pre-service teachers may not feel comfortable expressing doubts in or about their field placements or to a researcher affiliated with their university teacher education program.

If doubt leads to reflection and learning, pre-service teachers who have reasons to doubt the effectiveness of the lesson may be more likely to conduct better analyses of their instruction. If their middle school students struggled to learn from their lesson, this could provoke pre-service teachers' doubts about the effectiveness of the lesson. Morris (2006) studied pre-service teachers' analyses of a transcript of a mathematics lesson of another teacher, not themselves, and the pre-service teachers who analyzed the lesson under the condition of being told that students struggled to learn from the lesson prior to reading the transcript conducted better analyses than the pre-service teachers who were not given any information about students' learning from the lesson prior to analyzing the transcript. In the case of Morris's (2006) study, a stronger analysis of teaching meant that the pre-service teachers linked their evaluation of teaching was linked to evidence of students' thinking and learning of mathematics. Results from this study may differ from Morris's (2006) previous study, as the pre-service teachers in Morris's study analyzed another's teaching, and the pre-service teachers in this study analyzed their own teaching.

Evaluating one's own teaching could be a dramatically different task in comparison to analyzing another's teaching, particularly for pre-service teachers. It may be even more difficult to attend to students' thinking when a pre-service teacher analyzes her own teaching, as she may be more focused on her own performance with implementing the lesson or managing students' behavior. Alternatively, when analyzing one's own teaching, a pre-service teacher may conduct

a more nuanced analysis of the lesson because she may be more invested in its outcome than when analyzing a transcript of another's teaching.

With respect to revisions to the lesson, we might expect that pre-service teachers do not revise the lesson as aligned with the initial conceptual learning goal if their students struggled to learn the content. Researchers (Borko, Eisenhart, Brown, Underhill, Jones, & Agard, 1992; McDuffie, 2004) have illustrated that student teachers and novice mathematics teachers fall back on traditional approaches to teaching mathematics to reach their students when their students are struggling to learn mathematics content, perhaps due to a lack of pedagogical content knowledge.

### Methods

We took a qualitative approach to studying teacher efficacy by analyzing pre-service middle school mathematics teachers' self-reports of their criteria for determining the effectiveness of their mathematics instruction. Data were collected during a methods course specifically for pre-service middle school mathematics teachers in a teacher education program at a university in the Mid-Atlantic region of the USA in the fall of 2005. 33 pre-service teachers (3 male, 30 female) participated in this study. Two sections of the methods course were offered in the fall of 2005, and one of the sections of the course was taught by the first author.

#### *Context of Teacher Education Experiences*

Prior to their experience in this course, these pre-service teachers had already taken five mathematics education courses as a part of their teacher education program. Four of the courses were mathematics content courses for elementary and middle school teachers: number / place value and operations, rational number concepts and operations / proportional reasoning, geometry, and algebra. The fifth course was their first mathematics curriculum and methods

course for grades K-8. The pre-service teachers taught twice in their field placement and reflected on their teaching as a part of their first methods course, so teaching conducted in their field placement in the context of their middle school mathematics curriculum and methods course was not the first time these pre-service teachers had taught mathematics in classrooms, but in most cases this was the first time these pre-service teachers had taught in middle school classrooms. Other than being asked to reflect on their teaching in light of students' learning in this and their previous mathematics methods course, these pre-service teachers did not experience interventions to help them develop analysis of teaching skills. Thus, this study describes entry level skills of pre-service teachers for evaluating their own instruction.

These data are of pre-service teachers' evaluations of their instruction after teaching in different classrooms using the same lesson plan. The lesson plan was written the previous semester, the spring of 2005, by a small group of middle school mathematics student teachers. The pre-service teachers were told that they were going to teach this lesson and revise it based on data from their students to improve the lesson. The learning goal for the lesson was as follows: "Students will begin to develop an understanding of the division of fractions algorithm, or why the invert and multiply algorithm makes sense, for the cases when the divisor is a unit fraction." Notice that the learning goal focuses on developing meaning for a mathematical procedure. The learning goal was not written to emphasize the development of fluency with this procedure. Additionally, the learning goal addressed understanding this procedure only in the case when the divisor, or the second fraction in the division problem, is a unit fraction, or a fraction such that 1 is the numerator and any number is in the denominator. The learning goal was not written for the middle school students to develop an understanding of the division of fractions algorithm for all cases.

The activities in the lesson involved using various representations to explore division of fractions. A warm-up in the lesson involved exploring the concept of division and part-whole relationships in fractions. The next activity involved guided exploration as a whole class in which pre-service teachers walked middle school students through situations such as “How many halves of a paper plate fit into three paper plates?” This particular situation illustrated a how three divided by one-half could equal six, because six copies of one-half fit into three. The pre-service teachers used visual aids of paper plates in the front of the room during this guided discussion. Then the pre-service teachers set up an activity for the middle school students in which the middle school students used pattern blocks to explore division of fractions in small groups. For example, if the yellow hexagon was 1, and 6 green triangles fit into 1 hexagon, this would show 1 divided by  $1/6$ . Alternatively, if the red trapezoid was 1, and 3 green triangles fit into 1 hexagon, this would show 1 divided by  $1/3$ . The middle school students were asked to explore various relationships such as these and to write down their observations in a table. The pre-service teachers were then expected to conduct a large group discussion about the relationships discussed by the middle school students in their small groups.

At the end of the lesson, middle school students completed a short quiz, or post-lesson assessment, in which they were asked to divide a whole number by a unit fraction for the first three items and then to divide a whole number by a non-unit fraction on the last item. The purpose of the last item was to determine whether they could transfer their diagramming for division to another problem context.

#### *Data Collection*

Data were collected in the form of interviews and questionnaires in which pre-service teachers responded to the same questions. Seven of the participants were interviewed by

doctoral students studying mathematics education and 25 completed an open-ended questionnaire. The interviews were conducted prior to the administration of the questionnaires for the purpose of piloting the questions. Examples of questions included the following: “Do you think the students learned what you hoped they would learn from this lesson? How do you know? If you could have changed anything about your experiences teaching this lesson in order to improve students’ learning, what would you have changed?” (The full set of questions is contained in the appendix.) Data was collected within three weeks of when they taught this lesson.

### *Data Analysis*

Data were analyzed through a constant comparative process (Glaser & Strauss, 1967) with a focus on determining the nature of the pre-service teachers’ agent, means, and ends criteria used for evaluating the effectiveness of their lessons as well as the nature of revisions they suggested for teaching the lesson again. The first author and the second author each read through interviews to develop initial themes in the data. Then the first author consulted with a graduate student who enrolled full-time in our mathematics education masters program the year after her student teaching experience, so she was familiar with the goals of our mathematics teacher education program and the experiences of the participants, and we discussed various interpretations of the data.

The first author then developed a set of codes that characterized various criteria pre-service teachers used to evaluate their teaching with respect to ends (student outcomes), agent-means (how they, as the teacher, implemented the lesson), means-ends (how features in the lesson led to student outcomes), and agent-means-ends (whether the teacher implemented the lesson in a way that led to particular student outcomes). Additionally, codes were developed to

characterize revisions suggested for teaching the lesson with respect to the degree to which these revisions appeared to deviate from the initial learning goal of the lesson. These codes were discussed with the second author and another analyst, a doctoral student in mathematics education familiar with the goals of the study. Every participant's open-ended responses were independently coded by two coders, and consensus was reached between the two coders for any disagreements. Reliability analyses are currently in progress.

The unit of analysis was an evaluative statement, which consisted of either a phrase or a sentence that indicated judgment about the effectiveness of the lesson, and a revision statement, which was a phrase or a sentence in which the pre-service teacher suggested amendments to the instruction. An evaluative or revision statement could receive multiple codes. If the participant discussed both ends and agent or means criteria for effectiveness in the same evaluative statement, then the coder indicated a link between agent-ends, means-ends, or agent-means-ends criteria in the evaluative statement.

In this paper, we present results of evaluative and revision statement made by from half of the participants ( $N = 16$ ). These participants are those whose data has been double coded. Thus, results presented in this paper are preliminary. However, the first author has conducted an initial pass of coding the data set, and these results do not appear to contradict the themes across the entire data set.

## Results

The results from this study address the following questions: (a) What criteria do pre-service teachers use when evaluating their instruction? To what degree is their criteria aligned with their performance as a teacher (agent-means) or student outcomes? (b) What revisions do pre-service recommend as a part of their evaluations of their instruction? Are their revisions

aligned with the original learning goals for the lesson? (c) Do their evaluations of their instruction vary depending on their perceptions of their students' outcomes?

### *Criteria for Evaluating Instruction*

*Attention to student outcomes.* Pre-service teachers attended more often to ends, or student outcomes, when evaluating their instruction, in contrast to agent or means criteria. Looking across the codes assigned to the data set presented in this paper, 99 evaluative statements were coded for ends criteria, 49 were coded for means criteria, and 28 were coded for agent criteria. Based on the 99 evaluative statements when ends criteria codes were assigned, the lesson was more unsuccessful than successful with respect to students' learning outcomes, as 39 evaluative statements were coded with positive ends outcomes and 60 evaluative statements were coded with negative ends outcomes.

Within the evaluative statements coded for ends criteria, pre-service teachers' characterization of student outcomes was described generally rather than a nuanced description of students' understandings and misunderstandings, but when students did discuss a more detailed and nuanced sense of students' understandings, they did so when student outcomes were negative. (See Table 1.) When student outcomes were positive, they spoke of students getting the items on the post-lesson assessment correct or stated that the students understood or answered questions correctly during class. However, when pre-service teachers observed that the students were not learning, they discussed their performance in greater detail, such as saying the students struggled to draw representations for division, lacked specific prior knowledge, or struggled to complete the charts and tables designed for the lesson. Table 1 presents the percentages of types of ends criteria for students' learning outcomes; percentages were calculated in terms of the

number of participants' evaluative statements assigned to that code out of the 16 participants coded for this paper.

Table 1: Ends Criteria - Students' Learning Outcomes

<i>Positive</i>		N = 16	%
Students understood	"They seemed to have grasped the concept."	9	56.25
Students performed well on post-lesson assessment	"Based on the students who filled in answers, many seemed to answer the questions correctly."	4	25
Students answered questions well during class	"I observed their understanding through the responses they were giving me to critical questions..."	4	25
<i>Negative</i>			
Students did not understand	"I don't think students learned what I wanted them to learn."	10	62.5
Students did not perform well on post-lesson assessment	"The students could not solve the problems on the exit ticket."	10	62.5
Lack of connection between the class activity and concepts	"The students did not relate the table to the division of fractions algorithm."	10	62.5
Students filled out a chart without making appropriate conceptual connections	"I think the students were more concerned with following the pattern of the chart so that they could fill it in than learning the concepts."	8	50
Students lacked prior knowledge	"The lesson was too advanced for my students..."	5	31.25
Students struggled to draw diagrams to represent division of fractions	"They had no idea how to show it pictorially."	3	18.75

Pre-service teachers also discussed students' engagement when evaluating the effectiveness of their lesson, but to a lesser degree. Only 16 of the 99 evaluative statements coded for ends criteria reflected descriptions of students' engagement or behavior during the lesson, and these statements were half positive, half negative. When pre-service teachers characterized the student outcomes from the lesson, they focused on students' learning rather than their behavior.

Table 2: Ends Criteria - Students' Engagement

<i>Positive</i>		N = 16	%
Students participated	“Students were engaged and there was plenty of participation.”	6	37.5
Students were interested	“I was able to tell that they enjoyed the lesson...”	4	25
<i>Negative</i>			
Students did not behave well	“They were very rowdy.”	4	25
Students were not interested	“Many students became bored.”	4	25

*Critiquing the lesson, praising themselves.* Pre-service teachers were more likely to critique the lesson (means) rather than themselves or how they implemented the lesson (agent). They were more likely to praise their implementation of the lesson (agent) than the design of the lesson (means). Participants were asked to evaluate their overall sense of the effectiveness of their teaching and the effectiveness of the lesson separately. More participants attributed ineffectiveness to the lesson than their teaching in their overall evaluation. (The following percentages were from the entire data set (N = 33) rather than the subset of 16.) When evaluating their teaching, 9% of the participants said that it was very effective, 75% said somewhat effective, and 16% said neither effective nor ineffective. When evaluating the division of fractions lesson, 3% said very effective, 41% said somewhat effective, 5% said neither effective nor ineffective, 34% said somewhat ineffective, and 6% said very ineffective. Additionally, 49 instances of means criteria were coded in the open-ended data, while 28 instances of agent criteria were coded, and pre-service teachers spoke about means criteria more often in a negative manner and agent criteria more often in a positive light. (See Tables 3 and 4.)

The most frequently mentioned means criteria mentioned by the pre-service teachers when evaluating their lesson were criticisms of the lesson and its design.

Table 3: Means Criteria

<i>Positive</i>		N = 16	%
The lesson's activities were in an effective sequence	"The first two activities led into each other very well..."	3	18.75
<i>Negative</i>			
The lesson lacked relevance to the students	"The lesson had nothing to do with what they were working on in class."	8	50
The chart designed for the lesson was flawed	"The charts were far too lengthy, were too confusing, and consumed too much time."	6	37.5
The lesson's activities were not in an effective sequence	"The lesson seemed disjointed."	4	25
Disconnect between the problems on the post-lesson assessment and the lesson activities	"I do not think the post-test was reflective of what the students learned in the lesson."	4	25
The lesson was too long	"I think there were too many activities planned for the students during the lesson."	3	18.75

The most frequently mentioned agent criteria used by pre-service teachers when evaluating their lessons were positive evaluative statements.

Table 4: Agent Criteria

<i>Positive</i>		N = 16	%
The teacher posed good questions.	"I made sure to ask plenty of questions to guide them in the right direction."	5	31.25
The teacher managed the class effectively.	"I kept the students engaged during the lesson."	4	25
The teacher effectively enacted the intent of the lesson.	"I did teach what I was supposed to teach."	2	12.5
The teacher made the mathematical language accessible to students.	"I put the lesson in more understandable terms."	2	12.5
<i>Negative</i>			
The teacher did not manage the class effectively.	"I believe the main issue was management during this lesson... it was hard for me to enforce rules."	2	12.5
The teacher's role was too strongly authoritative; she told too much.	"I was simply giving the students a formula to use, which seemed like the easy way out as a teacher."	2	12.5
The teacher struggled to	"I felt it was hard to make adjustments	2	12.5

make adjustments to the lesson.	on the spot.”		
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*Emerging skill: Hypothesizing links between teaching and students’ learning.* When pre-service teachers evaluated their instruction, 12 out of 16 (75%) participants linked their evaluations of agent-means or means criteria to ends, or student outcomes, at least once. However, most of the pre-service teachers’ evaluations of their instruction described their criteria without a strong connection among the agent, means, or ends criteria.

The evaluation of their teaching that linked agent, means, and ends criteria that was mentioned most frequently was positive; the teacher posed good questions, which supported students’ learning. The most common means criteria that were mentioned in connection with ends criteria were both negative, and addressed issues of lesson sequence and lack of difficulty in the lesson.

Table 5: Evaluations Linking Teaching and Learning

<i>Positive</i>		N=16	%
The teacher posed good questions and the students responded well.	“I asked the students many probing questions to make sure they understood the concept and they answered them correctly.”	3	18.75
<i>Negative</i>			
The lesson was not sequenced effectively and this inhibited students’ learning.	“The activities did not connect well with each other and the students’ reactions showed that they were not making connections between the different activities.”	3	18.75
The lesson was too easy for the students.	“It was a little too easy for them and did not challenge them enough to promote student learning.”	3	18.75

### *Revisions to the Lesson*

Most of the pre-service teachers’ suggested revisions to the lesson were not inconsistent with the learning goal. The most common revision suggested by the pre-service teachers was

that they wished they had more time to teach the lesson; this was stated by 7 of the 16 pre-service teachers (43.75%). The other most common revisions suggested were also not inconsistent with the learning goal. 5/16 (31.25%) wanted to change the headings of the chart, 25% wanting to give students more time to explore or work in groups, and 25% wanted to provide students with more experiences with additional manipulatives or representations. (Note that participants may have mentioned more than one revision.) 25% suggested revising the lesson to include more practice problems so that students could master the division of fractions algorithm, but this revision was not aligned with the learning the learning goal. Additional revisions were not mentioned at a high degree of frequency across the sample.

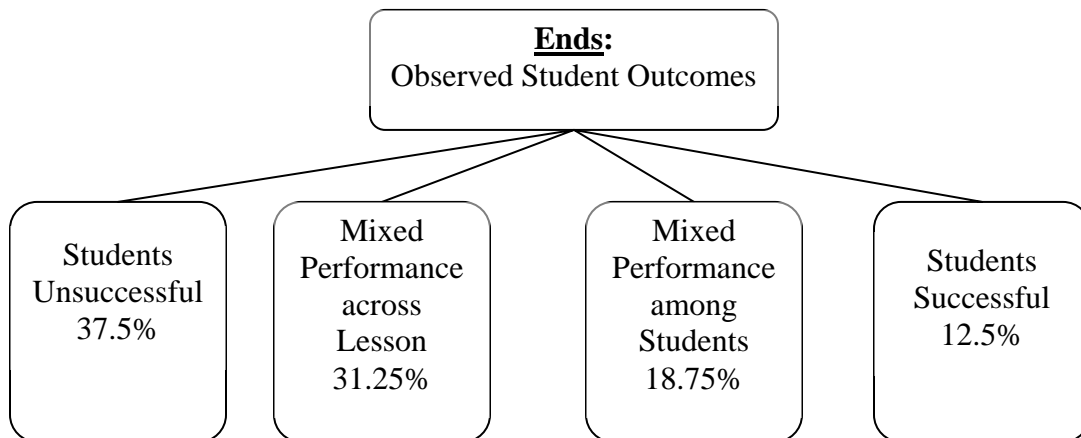
Table 6: Suggested Revisions to Lesson

		N=16	%
More time needed to teach for this learning goal	“I think the revision that would be most beneficial to the students would be to separate the lessons into two because this would allow for the students to spend more time focusing on one topic at a time.”	7	43.75
Adjust or omit the chart designed for this lesson	“I would alter the chart worksheet so that the pattern was not so visible for the students to do.” “I would not have used both charts and just focused on one.”	5	31.25
More group work and opportunities for students to explore	“The students needed to be in groups and spend more time exploring relationships on their own.”	4	25
More representations, visual aids, or manipulatives	“Also, I think the students wished to be more engaged in the activity, so if a new activity included manipulatives, it might keep the students more focused on the lesson. Instead the lesson had too much down time.”	4	25
More practice problems for students to master the division of fractions algorithm.	“Allowing the students to have more practice with the methods before giving them the posttest would definitely be beneficial to promoting students’ learning.”	4	25

### *Variations between Evaluations by Student Outcomes*

Due to the emphasis of ends criteria used by pre-service teachers when evaluating the lessons, we grouped the pre-service teachers by the student outcomes they observed, and we compared their evaluations of their instruction between the groups. There were four groups of observed student outcomes: (a) students unsuccessful, (b) mixed performance across the lesson, (c) mixed performance among students, and (d) students successful,. Pre-service teachers who observed at least some positive student outcomes (students successful or mixed performance among students) were more likely to evaluate their instruction with links between their teaching or the lesson and students' learning.

Figure 2: Observed Student Outcomes

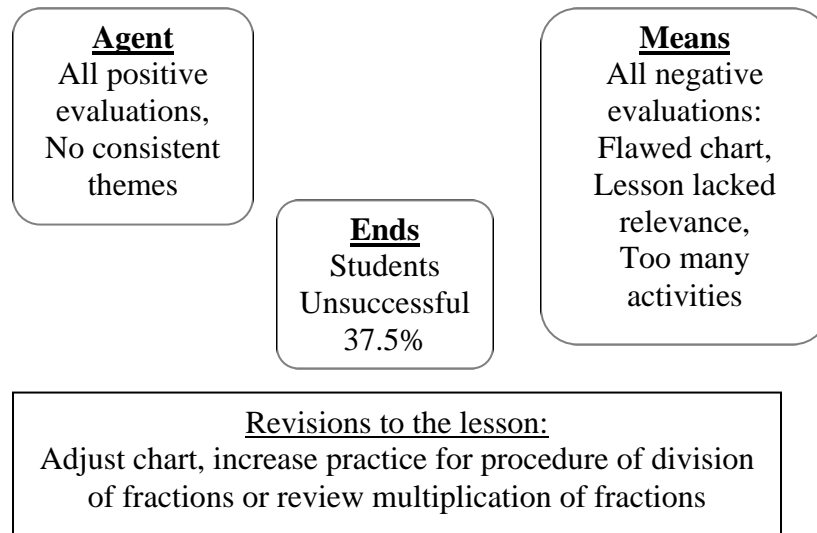


*Students unsuccessful.* Six out of 16 (37.5%) pre-service teachers determined that their students were unsuccessful and that their students did not achieve the learning goal. Their evidence of students' lack of understanding was usually from observations during class for all six of these pre-service teachers. (For one of these pre-service teachers, evidence was from the post-lesson assessment.) Students were discussed as a collective group without much of a sense that some students in this group may have understood or performed well, yet their group level

misunderstandings were described in more detail in comparison to how learning outcomes were described by pre-service teachers who observed that their students were successful.

While positive evaluations about the design of the lesson (means) were rare across the sample, the least positive comments about the lesson were among this group of pre-service teachers. This subgroup of participants was the least likely to evaluate their teaching in a manner that linked teaching to students' learning, as only half of the participants discussed their criteria for evaluating their instruction with any links between agent, means, and ends, and there were no consistencies among this group in the links they made. No arrows are drawn linking agent, means, or ends criteria in Figure 3 to illustrate the lack of links made between the criteria in pre-service teachers' evaluations.

Figure 3: Evaluation by Pre-Service Teacher whose Students Were Unsuccessful



When this subgroup of pre-service teachers revised their lessons, half of them suggested revisions that adjusted the learning goal to emphasize the development of procedural fluency or suggested approaches to teaching that de-emphasized the development of students' autonomy in doing mathematics, which was not consistent with the original intentions of the lesson.

However, half of the pre-service teachers in this group suggested revisions that were not

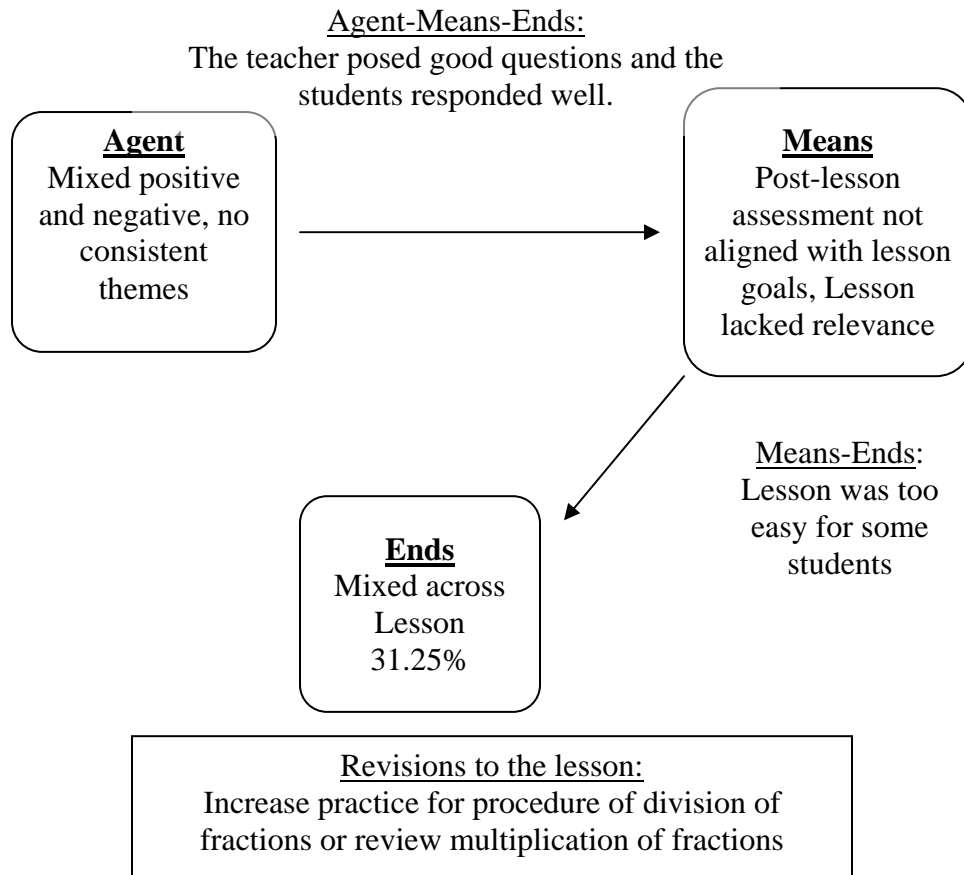
inconsistent with the original learning goal of the lesson, so it was not necessarily the case that revisions would be inconsistent with the learning goal if students were observed to be unsuccessful.

*Mixed performance across the lesson.* Five out of 16 (31.25%) pre-service teachers observed that their students appeared to understand during the lesson, but they did not perform well on the post-lesson assessment. These pre-service teachers contrasted evidence that suggested students were learning during the lesson with evidence that students did not learn from the post-lesson assessment.

Three of four pre-service teachers (among the entire group of 16) who noted that the post-lesson assessment was not directly tied to the learning goal were in this subgroup. The post-lesson assessment contained division problems very similar to those discussed during the lesson (other than the last problem with the divisor as a non-unit fraction), but the students could have solved the problems procedurally. The assessment did not capture optimally whether students understood the meaning of the operation, which was the conceptual learning goal of the lesson. Neither the instructors of the course nor the pre-service teachers attended to this issue when planning to teach, but the pre-service teachers who noted this discrepancy after they taught the lesson were mostly among this subgroup.

This subgroup evaluated their teaching as connected to students' learning, as four out of five of the pre-service teachers in this sample made one linked evaluation between teaching (agent or means criteria) and student learning. Representative linked evaluations are characterized in Figure 4.

Figure 4: Evaluation by Pre-Service Teacher whose Students' Performance was Mixed across the Lesson



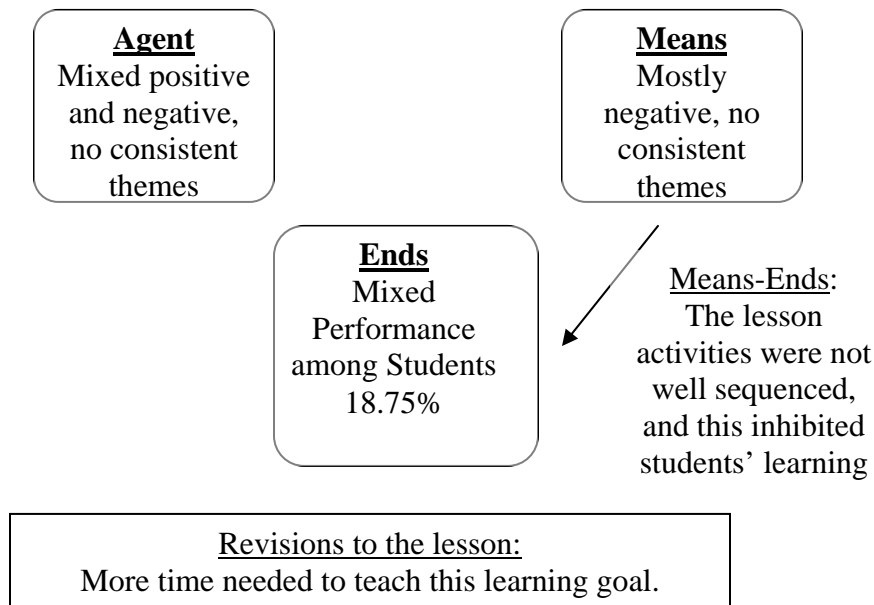
When suggesting revisions to the lesson, four out of the five pre-service teachers in this group adjusted the learning goal suggested to emphasize the development of procedural fluency or suggested approaches to teaching that de-emphasized the development of students' autonomy in doing mathematics.

*Mixed performance among students.* Three out of 16 (18.75%) pre-service teachers observed that some of their students learned or achieved the learning goal while others did not. Evidence for their evaluation came from observing their students during class and their performance on their post-lesson assessment. These pre-service teachers were able to think about subgroups of their students rather than characterizing the group as a whole, which is a

strong evaluation with respect to ends criteria, as it is more likely that there would be variation, to some degree, within a group of students.

This subgroup was likely to evaluate their teaching in a manner that linked teaching to students' learning. Every participant discussed criteria for evaluating their instruction in such a way that they linked between agent, means, and ends, and each of them did so twice. A representative linked evaluation is included in Figure 5.

Figure 5: Evaluation by Pre-Service Teacher whose Students' Performance was Mixed within the Group



All pre-service teachers in this subgroup said, when suggesting revisions to their lesson, that they needed more time to teach the lesson.

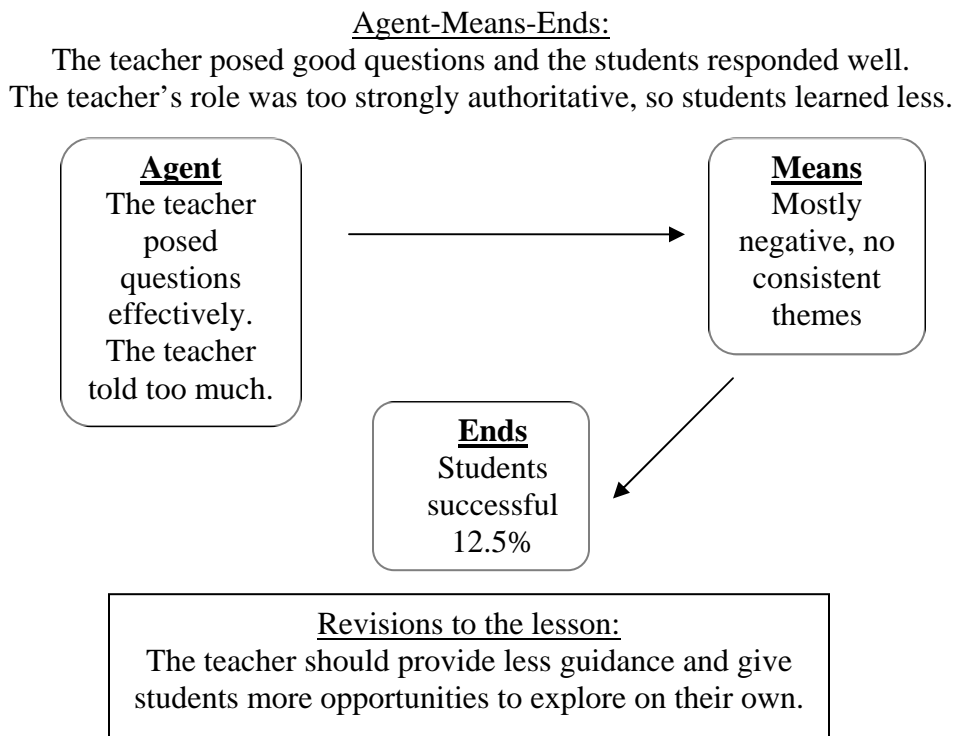
*Students successful.* Two out of 16 (12.5%) pre-service teachers determined that their students were successful at achieving the goals of the lesson, and these pre-service teachers wanted to push their students further to help their students make sense of the procedure for division of fractions when the divisor was a non-unit fraction. Evidence of students understanding was from students' performance on their post-lesson assessment. These pre-

service teachers discussed their students as a collective group rather than distinguishing between subgroups of their students..

This subgroup was likely to evaluate their teaching in a manner that linked teaching to students' learning. Every participant discussed criteria for evaluating their instruction in such a way that they linked between agent, means, and ends, and each of them did so twice.

Representative linked evaluations are featured in Figure 6.

Figure 6: Evaluation by Pre-Service Teacher whose Students were Successful



These pre-service teachers wanted to decrease the amount of guidance they gave when teaching, as indicated by their agent criteria and revisions to the lesson. Their focus on helping their students understand division when the divisor was not a unit fraction extended the learning goal beyond its original design, so perhaps these pre-service teachers were thinking about what they would teach in the next consecutive lesson when evaluating the lesson.

## Discussion

### *Criteria for Evaluating Instruction*

*Attention to student outcomes.* Data in this study illustrates that pre-service teachers can and do consider student outcomes when evaluating their instruction, suggesting an emergence of pedagogical thinking (Feiman-Nemser & Buchmann, 1986), yet their attention to student outcomes was not very nuanced. Students were regularly discussed as a collective group, either understanding the lesson or not (Otero, 2006). When the pre-service teachers discussed their middle school students' mathematical thinking in a more nuanced manner, it was when their students were struggling to learn. The pre-service teachers did not focus on issues of students' engagement or behavior over students' understanding or achievement.

We wondered whether pre-service teachers' focus on student outcomes was a function of the data collection methods, and we determined this was not entirely the case, as pre-service teachers responded with attention to ends criteria to open-ended items that did not specifically ask them to consider issues of students' learning or engagement (e.g., Appendix, #1). The data was collected in the context of a course in which the pre-service teachers were asked to regularly discuss effectiveness of their lessons and other teachers' lessons (in cases, video vignettes, etc.) in light of students' thinking, so the context may have focused their thinking on student outcomes.

What supports pre-service teachers' maintenance of a focus on students' thinking when evaluating their instruction outside of the context of the methods course, as they move into student teaching or their first years of teaching?

*Critiquing the lesson, praising themselves.* Pre-service teachers were more likely to criticize and doubt the design of the lesson rather than themselves as a teacher. The lesson was

designed by others, by student teachers from the previous semester, which may have led to a more striking distinction between themselves as the teacher, or agent, and the lesson, or the means of reaching the students, than how teachers more commonly evaluate their instruction. In the context of being asked to revise a lesson written by others, pre-service teachers had an opportunity to doubt and reflect upon how to teach their students in a way that could preserve their own identities as potentially good mathematics teachers. It would be more threatening to critique one's implementation of the lesson than it would be to critique the design of the lesson itself. Helping teachers externalize the lesson design from their own abilities as a teacher to implement the lesson has potential for promoting learning.

*Emerging skill: Hypothesizing links between teaching and students' learning.* While most of the pre-service teachers' evaluative statements about their instruction did not link issues of teaching (agent or means) to students' learning, 75% of the pre-service teachers did make such a link at least once, and pre-service teachers with some positive student learning outcomes (students were successful or mixed performance among the students (some were successful)) were more likely to make these links. This connection among agent, means, and ends criteria seems important for developing pedagogical thinking in that the pre-service teachers begin to consider whether they can hypothesize links between their teaching and students' learning.

The results of this study contrast with Morris (2006), who found that pre-service teachers were more likely to link issues of teaching to students' learning under a condition when they analyzed teaching and were told that students' struggled to learn the material. A difference between these two studies may be that analyzing one's own teaching, as in this study, directs an evaluation of instruction differently than when analyzing another's teaching, as in Morris's (2006) study. When analyzing one's own teaching, the features of instruction that helped

students learn may be clearer when the lesson goes well. Sample sizes were similar, but rather small, in both studies. Future research should continue to examine whether positive or negative student outcomes are likely to elicit analyses of teaching that are linked to students' learning, depending on whether the analysis is of one's own teaching or that of others'.

### *Revisions to the Lesson*

While most of pre-service teachers' suggested revisions to the lesson were not inconsistent with the learning goals, they were likely to suggest revisions not aligned with the learning goal when students struggled to learn the material. Additionally, in one case when students were successful, revisions were suggested to extend the learning goal to help students understand division with a non-unit fraction in the divisor. Additionally, revisions may have appeared to align with the original conceptual learning goal or may have appeared to promote students' autonomy, but they were stated at such a general level that it was difficult to tell. Suggesting that students have more opportunities to explore in groups and to work with manipulatives are superficial lesson features that may or may not help their students develop conceptual understanding, depending on their implementation.

One way of interpreting revisions to a lesson that appear to be misaligned with the learning goal is that teachers expect to interact with students over time. If they adjust the lesson to back up and address a different learning goal that supports prior knowledge for achieving the intended learning goal or adjust the lesson to extend the learning goal beyond the intended learning goal to present further challenges to their students, this may be due to teachers considering how to teach a unit related to the original learning goal rather than the individual lesson. Conceptualizing a trajectory of goals in relation to one another is a strong skill that teacher educators would like to foster in pre-service teachers.

However, adjusting the learning goal to focus on procedural fluency when the original learning goal addressed conceptual understanding is a different revision that suggests beliefs about learning mathematics such that conceptual understanding can only follow procedural fluency. Research on students' learning suggests that the development of procedural fluency can follow the development of conceptual understanding; there is no fixed order in learning skills or concepts, as sometimes procedures can be learned first and other times concepts can be learned first (Rittle-Johnson & Siegler, 1998). Procedural fluency does not always have to come first. Addressing beliefs about learning mathematics in the context of methods courses takes on a particular importance when evaluating the instruction of lessons designed with a conceptual learning goal.

#### *Variations between Evaluations by Student Outcomes*

We examined whether pre-service teachers' observations of their students' outcomes mediated their evaluations of their instruction. If a better evaluation of instruction links teaching (either agent or means criteria) with student outcomes (ends), describes student outcomes in a nuanced manner, and suggested revisions aligned with the initial learning goals, having some positive student outcomes elicited better evaluations, since the only group not to evaluate instruction with these links was the group of pre-service teachers that did not observe any positive student outcomes. However, when pre-service teachers observed negative student outcomes, they discussed the nature of their students' misunderstandings with more nuance and in greater detail than the pre-service teachers who observed their students to be successful. Pre-service teachers who observed negative student outcomes were more likely to suggest revisions to the lesson that were not aligned with the learning goal, but this was not always the case. Negative student outcomes provided more opportunity to reflect upon the nature of students'

understanding, but provided challenges for revising instruction and linking teaching to students' learning. Positive student outcomes provided a mastery experience for teaching a lesson with a conceptual learning goal in that revisions were likely to be aligned with the initial goal and evaluations had links between teaching and students' learning.

#### *Teacher Efficacy among Pre-Service Mathematics Teachers in Reform Mathematics Contexts*

These pre-service teachers were evaluating their instruction in the context of a teacher education program that promotes teaching mathematics for conceptual understanding in balance with procedural fluency and in such a way that would promote mathematical autonomy in students. Their agent-means criteria that they used to evaluate their instruction positively illustrate opportunities for new teachers to feel efficacious in the context of teaching to meet the goals of the mathematics education reform movement. In particular, these pre-service teachers mentioned posing questions effectively and helping their students access mathematical language. They wrestled with whether or not they were too strong of an authority figure in the classroom. These criteria for evaluating their teaching are in contrast to basing their teaching efficacy on the clear delivery of a well-sequenced and designed lecture. However, a mathematics teacher does need to step in and deliver mathematics content to their students when appropriate.

#### *Implications for Teacher Education*

There is often resistance from pre-service teachers when they are asked to teach from a common lesson plan, as they mention how challenging it is to teach a lesson that is disconnected from their students' curriculum. In this situation, when pre-service teachers are asked to teach from a common lesson plan for the purpose of improving it based on data collected about students' thinking, this allowed them to preserve their own sense of efficacy about their teaching, as agent-ends efficacy has been found to be high among teachers during their teacher education

programs (Hoy & Spero, 2005), yet they had opportunities to doubt the effectiveness of the instruction and learn from the teaching experience (Wheatley, 2002) by externalizing the problems onto the design of the lesson.

A challenge for teacher educators is supporting the development of pedagogical content knowledge of pre-service teachers so they can maintain a conceptual learning goal when revising a lesson. Results of this study complement previous findings (Borko, et al, 1992; McDuffie, 2004) that describe new mathematics teachers falling back on traditional approaches to teaching mathematics when their students struggle to learn. Interventions designed to develop pedagogical content knowledge for the purpose of revising lessons to address conceptual understanding are needed.

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## Appendix

*Questionnaire / Interview Items*

1. Consider your first lesson that you taught in your field placement about division of fractions. Did the lesson go well or not? Explain.

2. What did you hope students would learn from this lesson?

3. More specifically, do you think the students learned what you hoped they would learn? How do you know? Why do you think they did or did not learn this?

4. If you could have changed anything about your experiences teaching this lesson in order to improve students' learning, what would you have changed? Which of these changes would be most beneficial to promote students' learning? Why?

5. How would you evaluate your teaching during this lesson?

- (a) Very effective
- (b) Somewhat effective
- (c) Neither effective or ineffective
- (d) Somewhat ineffective
- (e) Very ineffective

Explain your reasons for this choice.

6. For this question, think about the design of the lesson itself rather than your teaching: Overall, to what degree would you say this lesson was an effective lesson?

- (a) Very effective
- (b) Somewhat effective
- (c) Neither effective or ineffective
- (d) Somewhat ineffective
- (e) Very ineffective

Explain your reasons for your choice.

### Authors' Notes: Acknowledgements

Preparation of this paper was supported, in part, by the National Science Foundation, Grant 0083429 to the Mid-Atlantic Center for Teaching and Learning Mathematics. The opinions expressed in the article are those of the authors and not necessarily those of the Foundation.

The authors would like to thank those who assisted with this study. Betsy Read taught the additional section of the middle school mathematics curriculum and methods course. Christine Phelps, Nicola Edwards-Omolewa, and Delayne Johnson participated in conducting interviews, so the instructors of the course did not have to do so. Rachel Francis assisted with providing some initial interpretations of the data based upon her experiences in the teacher education program. Sandy Greene assisted with data analysis.