Preservice elementary teachers' adaptation of science curriculum materials: Initial attempts at curriculum design for inquiry

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Abstract

Curriculum materials are important tools with which teachers can engage students in inquiry. In order to use curriculum materials effectively, however, teachers must develop a robust capacity for pedagogical design, or the ability to mobilize a variety of personal and curricular resources to promote student learning. The purpose of this study is to develop a better understanding of the ways in which preservice elementary teachers mobilize and adapt existing science curriculum materials to plan inquiry-oriented science lessons. Specifically, using quantitative methods, we investigated the preservice teachers' curriculum design decision-making and how these decisions influence the inquiry-orientations of their planned lessons. Findings indicate that preservice elementary teachers are able to accurately assess how inquiry-based existing curriculum materials are and to adapt them to make them more inquiry-based. However, how inquiry-based their lessons ultimately are is in large part determined by how inquiry-based the curriculum materials they used to plan their lessons were to begin with. These findings have important implications for science teacher educators and science curriculum developers, particularly as related to the design of inquiry-oriented science curriculum materials and emphasizing the use of these artifacts in science teacher education.

Current science education reform emphasizes the importance of inquiry-based science teaching and learning (American Association for the Advancement of Science, 1993; National Research Council, 1996). For their part, teachers need to engage in science teaching practices that facilitate and support students' science learning through inquiry. Teachers clearly play a critical role in scaffolding students' learning in the classroom. However, teachers' professional practice is not strictly limited to classroom teaching, or what they do in the classroom with students. Teachers also plan for and reflect upon their teaching. These practices, which constitute the design domain of teaching practice (Remillard, 1999), typically occur in the absence of students but are also important. It is through curriculum planning that teachers design science learning environments and learning experiences within and through which they can optimally support and facilitate students' engagement in inquiry-based science learning.

In planning for science teaching, teachers often rely on existing science curriculum materials, or lesson plans, worksheets, textbooks, and other resources that shape both planned and enacted instruction. As Shulman (1986) acknowledged decades ago, curriculum materials are one of a teacher's most important tools. Particularly in science, curriculum materials have historically served as vehicles for reform, playing an important role in communicating to teachers what and how science should be taught and learned (DeBoer, 1991). In this role, then, curriculum materials serve as a sort of blueprint for classroom activity through which teachers design, enact, and evaluate science teaching and learning.

Recent research has highlighted the important relationship that exists between teachers and curriculum materials, particularly the ways in which teachers mobilize their personal characteristics (knowledge, beliefs, orientations, and identities) to evaluate, critique, and adapt curriculum materials (Remillard, 2005). Ultimately, to effectively design science learning environments, teachers need to learn to mobilize their personal characteristics and curriculum materials in productive ways in light of affordances and constraints of their professional contexts. This particular notion of teaching expertise is referred to as teachers' *pedagogical design capacity* (PDC - Brown, 2002, in press; Remillard, 2005).

Consistent with both temporal and situated perspectives on teacher learning (Feiman-Nemser, 2001; Putnam & Borko, 2000), a teachers' capacity for pedagogical design evolves over time and across contexts along the teacher professional continuum. As such, preservice teachers need to be supported to begin developing their pedagogical design capacity for inquiry-based science. This is particularly important since beginning teachers often articulate conceptions of inquiry that are inconsistent with those advocated in science education reform and rely heavily on curriculum materials to which they have access (Abell, 2007; Grossman & Thompson, 2004; Kauffman, Johnson, Kardos, Liu, & Peske, 2002; Windschitl, 2004). Focusing on the development of preservice teachers' pedagogical design capacity can help insure that they enter teaching as 'well-started beginners' who are prepared to maximize opportunities to learn in and from professional practice.

Despite the need to support teachers' development of pedagogical design capacity for science at the preservice stage of the teacher professional continuum, we also know little about how to best design teacher education experiences that do so. Overall, there is little research that informs the field's understanding of preservice teachers' use of curriculum materials. A more recent body of research on preservice elementary teachers' use of and learning from science curriculum materials has begun to emerge (Davis, 2006; Dietz & Davis, in press; Forbes & Davis, 2008; Schwarz, Gunckel, Smith, Covitt, Enfield, Bae, & Tsurusaki, 2008). However, more research is needed to investigate preservice teachers' conceptions of inquiry as an instructional framework, how they instantiate those ideas in the adaptation of existing curriculum materials, and how this process is socially- and culturally-mediated. The specific goal of this study is to develop a better understanding of the ways in which preservice elementary teachers mobilize and adapt existing science curriculum materials to plan inquiry-oriented science lessons. Specifically, we asked a) *how many and what types of curriculum materials do they use and adaptations do they make?,* b) *how inquiry-oriented are their lessons before and after adaptation?*, c) *and what factors explain their ability to make existing science curriculum materials more inquiry-oriented?*.

Theoretical Framework

Teachers need to develop expertise for teaching. A substantial amount of education research has focused on characterizing teachers' knowledge, including subject-matter knowledge and pedagogical content knowledge, and beliefs (e.g., Abell, 2007). Ultimately, teachers draw upon their knowledge, beliefs, orientations, and identities, or personal characteristics, to engage in professional practice, including the use of curriculum materials, to plan and engage in science teaching. It has, however, proven more difficult to establish empirical relationships between teachers' personal characteristics and their practice. As a construct, PDC provides a framework through which to understand and analyze teachers' practice as a function of interactions between their personal characteristics, the curricular tools at their disposal, and features of their professional contexts.

Teachers need to develop robust pedagogical design capacity for science teaching. Broadly defined, PDC for science entails a synergistic relationship between teachers' personal characteristics that pertain to science teaching, the science curriculum materials they use, and features of their professional context that best promote students' science learning. An important characteristic of PDC is that it is a property of whole systems, not just individuals, and therefore foregrounds interactions between its constituent elements, not just the elements themselves (Brown, 2002, in press). One important interaction is between teachers' espoused inquiry frameworks and the curriculum materials they use to plan for science teaching. This is the relationship foregrounded in this study. To set the stage for this study, we next discuss existing research on preservice teachers' conceptions of inquiry and preservice teachers' use of curriculum materials.

Preservice Teachers and Inquiry

Current science education reform efforts prioritize inquiry-oriented science teaching and learning (AAAS, 1993; NRC, 1996, 2000). Classroom inquiry is designed to engage students in practices that mirror those of scientists, including engaging in scientifically-oriented questions, collecting, organizing, and analyzing data and evidence, constructing evidence-based explanations, comparing explanations to alternative explanations, and communicating and justifying methods and explanations. In order to engage students in standards-based, inquiry-oriented science, teachers must develop a thorough understanding of scientific inquiry and inquiry-oriented teaching practices, as well as orientations towards science teaching that are congruent with inquiry teaching and learning. As noted in *Inquiry and the National Science Education Standards* (NRC, 2000), "for students to understand inquiry and use it to learn science, their teachers need to be well-versed in inquiry and inquiry-based methods" (pg. 87). However, supporting teachers in developing requisite knowledge and abilities to engage in inquiry-oriented science teaching practice remains a challenge. As the NRC (2000) also acknowledges,

> …most teachers have not had opportunities to learn science through inquiry or to conduct scientific inquiries themselves. Nor do many teachers have the understanding and skills they need to use inquiry thoughtfully and appropriately in their classrooms. (pg. 87)

These sentiments are reinforced by a recent review of education research that focused on challenges preservice and beginning teachers face in science teaching (Davis, Petish, & Smithey, 2006). A major section of this review focused on teachers' knowledge and beliefs about scientific inquiry, the nature of science, and inquiry-oriented science teaching. Furthermore, a majority of articles reviewed by the authors involved the study of preservice elementary, middle, and secondary science teachers. There is some evidence that teachers, particularly preservice teachers, hold views of scientific inquiry and inquiry-oriented science teaching that are often inconsistent with those advocated in current science education reform documents.

Preservice teachers possess existing ideas about scientific inquiry and inquiry-oriented teaching practice (Howes, 2002). They often view the nature of science as a body of facts rather than negotiated and constructed through scientific practices (Gess-Newsome, 2002). Preservice teachers also often view these scientific practices, embodied by the field's conceptions of scientific inquiry, as linear and lockstep rather than dynamic and iterative (Windschitl, 2003). However, they can come to appropriate views of scientific inquiry that are more consistent with those articulated by science education scholars and scientists (Bryan, 2003; Gess-Newsome, 2002). Not surprisingly, a particularly powerful influence on preservice teachers' developing understanding of inquiry and inquiry-oriented practice is their involvement in authentic scientific investigations as part of teacher education (Haefner & Zembal-Saul, 2004; Windschitl, 2003). While preservice teachers can develop inquiry-specific knowledge, translating that knowledge into science teaching practice presents a more difficult task (Bryan & Abell, 1999; Crawford, 1999; Southerland & Gess-Newsome, 1999; Zembal-Saul, Blumenfeld, & Krajcik, 2000). They often struggle to develop more coherent views of inquiry-oriented science teaching (Smithey & Davis, 2002; Windschitl, 2004). However, there is encouraging evidence that preservice teachers can learn to engage in effective, inquiry-oriented science teaching over time (Crawford, 1999, 2007).

Preservice Teachers and Science Curriculum Materials

Just as preservice teachers possess existing ideas about science teaching, including inquiry, they also draw upon these ideas as criteria by which they critique and adapt science curriculum materials. Many of the criteria they employ are consistent with those intended by the curriculum developers (Dietz & Davis, in press) and advocated in current science education reform (AAAS, 1993; NRC, 1996, 2000). They also mirror those dimensions of science teaching practice that preservice elementary teachers prioritize elsewhere. For example, many studies have illustrated preservice elementary teachers' child-centered perspectives on teaching (Abell, 2007; Abell, Bryan, & Anderson, 1998; Howes, 2002; Levitt, 2002). Preservice teachers similarly draw upon these orientations in their critique and adaptation of science curriculum materials, specifically in their prioritization of student engagement and connections to students' lives outside of school (Davis, 2006; Forbes & Davis, 2008).

Similarly, elementary teachers emphasize active, hands-on science experiences for students in science (Abell, 2007; Abell, Bryan, & Anderson, 1998; Howes, 2002). Preservice elementary teachers also prioritize the investigative dimensions of inquiry and inquiry-oriented teaching in their use of science curriculum materials. Unfortunately, they often do so at the expense of explanation-construction, a crucial component of scientific inquiry (Davis, 2006). In fact, while novice teachers can learn to teach science as inquiry (Crawford, 1999), they often prioritize other relevant criteria over inquiry and inquiry-oriented science teaching (Dietz & Davis, in press). This is consistent with findings from other studies which found that preservice teachers generally possess less well-developed understandings of inquiry-oriented teaching practice (Smithey & Davis, 2002; Windschitl, 2004). However, preservice elementary teachers' generally positive orientations toward active, hands-on, investigation-based science can serve as a productive foundation upon which to support their developing understanding of scientific inquiry (Howes, 2002).

These studies also suggest that preservice teachers can learn to more effectively critique and adapt curriculum materials through teacher education. Scaffolded opportunities for learning in science methods courses can help preservice teachers first develop awareness of particular criteria and then learn to apply them over time in their use of curriculum materials (Davis, 2006). Additionally, preservice teachers can learn to use educative features of curriculum materials to support their development at this crucial stage along the teacher professional continuum (Dietz & Davis, in press; Schwarz et al., 2008). Preservice teachers also cite the active use of curriculum materials as more important for beginning teachers than experienced teachers but acknowledge that more experienced teachers also have the capacity to learn from curriculum materials in two cases: when using new curriculum materials and when teaching new content (Forbes & Davis, 2008). These studies also provide evidence that preservice teachers' learning to use curriculum materials is fundamentally intertwined with their developing identity as teachers (Dietz & Davis, in press; Forbes & Davis, 2008).

Methods

This study involved 46 preservice elementary teachers enrolled in two sections of an undergraduate elementary science teaching methods course. As part of the course, the preservice teachers completed two assignments in which they used existing science curriculum materials to plan inquiry-based science lessons and enact them in elementary classrooms. Using artifacts associated with those lessons, we analyzed the types and frequencies of curriculum materials the preservice teachers used and the adaptations they made, how inquiry-based their pre- and post-adaptation lessons were, as well as how these decisions helped explain how inquiry-based their adapted lessons were.

Participants and Context

This study took place during the third semester of an undergraduate elementary teacher preparation program at a large, Midwestern university in the United States. During the third semester, the preservice teachers are enrolled in the elementary science teaching methods course. There were two sections of the course. The first author was the instructor for one section while the other was taught by a colleague. The course was planned collaboratively over the summer and was designed to be consistent across sections. During the semester, the instructors met weekly and frequently attended each others' section meetings.

The science methods course itself was designed around two broad domains for preservice teacher learning: inquiry-oriented science teaching and the use of science curriculum materials. However, the scope and sequence of the course designed around a specific set of criteria, loosely derived from the Project 2061 criteria for the evaluation of curriculum materials (Kesidou & Roseman, 2002). These criteria are:

1. Learning goals alignment
2. Providing a sense of purpose

3. Eliciting and interpreting students' ideas
4. Engaging students in experiences with phenomena and representations
5. Promoting students' thinking about experiences and ideas
6. Assessing students' ideas
7. Supporting all students

These criteria were not only used in critiquing and adapting science curriculum materials over the course of the semester, but also in analyses of and discussions about examples of teaching practice and other activities in the methods course.

Through participation in the science methods course, preservice teachers develop familiarity with current science standards documents, such as the AAAS Benchmarks (AAAS, 1993), the *National Science Education Standards* (NRC, 1996), the *Michigan Curriculum Framework* (Michigan Department of Education, 1996), as well as numerous science curriculum programs. They prepare to teach inquiry-oriented lessons by engaging in investigations involving asking questions, making predictions, conducting experiments, collecting data, making observations, developing explanations, and communicating findings. They learn how to anticipate, identify, and address students' ideas in science, develop teaching skills by preparing an in-depth science investigation plan, build on existing curriculum materials gain experience in preparing, teaching, critiquing, and analytically reflecting on elementary school science lessons while working with young students in local schools. These experiences are designed to help the preservice teachers become increasingly autonomous, reflective professionals as they move toward the student teaching semester.

Between the two sections of the course, there were 50 preservice elementary teachers taking the science methods course in the Fall of 2007. All were traditional fourth-year seniors (about 21 years old) in their final year of college and representative of the population of elementary teachers in the U.S. in that most were female and most were Caucasian (National Center for Education Statistics, 2003). At the beginning of the methods semester, each student is presented with an opportunity to either agree or not agree to participate in any research undertaken during the term. This is done online and in private. The consent process determined how many preservice elementary teachers from the two sections of the methods course were included in the total study sample. In the Fall of 2007, all preservice teachers from the first author's section of the course agreed to participate in research. In the other section of the course, four of 28 preservice teachers chose not to participate. Data for this study are therefore drawn from 46 preservice teachers in two sections of the course (n_1=22, n_2=24). These 46 preservice teachers comprise the overall study population. Those who provided consent were reassured that they could withdraw their consent at any time, though none of them opted to do so.

Data Sources and Collection

During the methods semester, the preservice teachers were asked to plan and develop, teach, and reflect upon two science lessons. These assignments are called *reflective teaching assignments* (RTs) and are the two most substantial tasks in which the preservice teachers engage. From an instructional standpoint, the purpose of the reflective teaching assignments is to afford the preservice teachers an opportunity to gain experience planning, enacting, and reflecting upon inquiry-oriented science teaching using a variety of science curriculum materials. Specifically, the preservice teachers are asked to take an existing science lesson or set of science curriculum materials, critique them, modify them to develop an inquiry-oriented lesson, enact this lesson in their placement classrooms, and reflect on their teaching.

In completion of this assignment, the teachers submit the following artifacts: the original science lesson and/or curriculum materials they used, the lesson plan and lesson rationale they develop, a reflective journal through CASES, and a small sample of student work. The lesson plan format is designed to be consistent with those the preservice teachers have used in other methods courses in the teacher education program and would most likely expect to see in lessons they will use in the future. The lesson plan rationale consists of a number of scaffolds designed to support the preservice teachers in articulating their decision-making related to the mobilization and modification of science curriculum materials for inquiry. The post-enactment reflection similarly provides a number of prompts that are designed to support them to revisit these decisions based on their experience enacting the lesson.

Data Coding and Analysis

Quantitative analysis for this study involved lesson plans and other instructional artifacts from preservice teachers in both sections of the elementary science methods course (n=46). These lesson plans and instructional artifacts were from the two reflective teaching assignments completed by the preservice teachers over the course of the semester. The purpose of the quantitative analyses is to characterize the types and frequencies of curriculum materials the preservice teachers use, the types and frequencies of adaptations the preservice teachers make, and how inquiry-oriented their initial and revised science lesson plans are.

Data Coding

Three coding keys or rubrics were developed for this component of the study. In order to characterize the types and frequencies of science curriculum materials the preservice teachers use, we employ the coding key in Table 1.

Table 1

Coding Key for Types of Curriculum Materials

Type of Curriculum Materials	Description
Existing lesson plan (LP)	Preservice teacher uses an existing lesson plan to develop the science lesson he or she enacts.
Stand-alone investigation, experiment, or activity (AIE)	Preservice teacher uses stand-alone investigation, experiment, or activity to develop the science lesson he or she enacts.
Textbook (T)	Preservice teacher uses a textbook to develop the science lesson he or she enacts.
Content resource (science background information) (CR)	Preservice teacher uses a content resource to develop the science lesson he or she enacts.
Video/DVD (VD)	Preservice teacher uses video to DVC to develop the science lesson he or she enacts.
Models, graphs, or images (MGI)	Preservice teacher uses a separate model, graph, or image to develop the science lesson he or she enacts.
Trade book (story) (TB)	Preservice teacher uses a trade book to develop the science lesson he or she enacts.
Computer software (CS)	Preservice teacher uses computer software to develop the science lesson he or she enacts.
Student worksheet (SW)	Preservice teacher uses a student worksheet to develop the science lesson he or she enacts.
Other (O)	Preservice teacher uses a curricular resource not captured in the other categories to develop the science lesson he or she enacts.

To characterize the types and frequencies of changes preservice teachers make to these curriculum materials in their curriculum design efforts, we use the coding key in Table 2. These codes are consistent with how other researchers have characterized teachers' adaptations to curriculum materials (e.g., Drake & Sherin, 2006).

Table 2

Coding Key for Types of Adaptations to Curriculum Materials

Types of Changes	Description
Insertions (Ins)	Adds a new element to the lesson plan
Deletions (Del)	Deletes an element of the existing lesson plan
Substitutions (Sub)	Substitutes a new element for an existing element of a lesson plan
Duplications (Dup)	Includes an existing element from the lesson plan in another part of the lesson plan
Inversions (Inv)	Switches the order or placement of 2 or more existing elements of a lesson plan
Relocations (Rel)	Moves an existing element in the lesson plan to different location in lesson

Lastly, in order to assess the inquiry-orientation of the science lessons the preservice teachers developed, we used the inquiry scoring rubric included in the Appendix. This scoring rubric is informed by existing rubrics for the evaluation of science curriculum materials (Kesidou & Roseman, 2002) and science teaching (Bodzin & Beerer, 2003; Luft, 1999). It is explicitly designed to capture crucial elements of inquiry as defined in current science education reform (Grandy & Duschl, 2007; NRC, 1996, 2000). Davis and colleagues (2006) note that much of the existing research on preservice teachers' knowledge, beliefs, and orientations regarding scientific inquiry and inquiry-oriented practice focuses on specific practices that are circuitously related to inquiry as defined in current science education reform document . Most studies have not operationalized elements of scientific inquiry and inquiry-oriented science teaching as defined in current reform documents, including asking and answering scientific questions, prioritizing evidence and evidence-based explanation, and communicating and justifying findings and explanations (NRC, 1996, 2000). As Davis and colleagues (2006) argue, "without understanding these aspects of scientific inquiry, new teachers are unlikely to be successful at teaching through inquiry" (pg. 618). It is important that further research be undertaken to investigate novice teachers' ideas about and orientations toward scientific inquiry and inquiry-oriented science teaching in light of those dimensions specifically explicated in *The National Science Education Standards*. This is one goal of the study proposed here.

Data Analysis

Here, quantitative analyses are used to address our three research questions. These analyses were based on numerical and categorical data provided directly by the preservice teachers, as well as the quantification of qualitative data (Chi, 1997). Coding reports were produced for each preservice teacher's reflective teaching assignment documents. These reports summarized the types and frequencies of curriculum materials used and adaptations made, as well as an inquiry score for both their existing and revised lesson plans. For this coding, inter-rater reliability was performed with a colleague. For the codes in Tables 1, 2, and Appendix A, coding consistency for the preservice teachers' reflective teaching assignments ranged from 65% to 100%, averaging 82% agreement prior to discussion. After discussion, 100% agreement was reached. These quantified data, as well as survey data, were imported into SPSS for statistical analysis.

Quantitative analysis involved a number of steps. The first set of quantitative analyses focused on provided descriptive statistics and establishing statistically-significant relationships between variables. Using t-tests, chi-square tests, and ANOVA, we investigated relationships between individual teacher characteristics provided in the survey. Then, we provide descriptive statistics for the types and frequencies of both curriculum materials used and adaptations made to them for the preservice teachers' two reflective teaching assignments. Additionally, we investigated relationships between patterns of curriculum materials use in the first and second reflective teaching assignments using Pearson correlations. Next, we investigated the inquiry scores of the preservice teachers' science lessons, both before and after adaptation. We used t-tests, ANOVA, and Pearson correlations to compare these inquiry scores within and across the two reflective teaching assignments. For all statistical tests, measures statistical significance hav been provided. Also, consistent with the recent emphasis on reporting statistical power as well as significance (Olejnik & Algina, 2003; Thompson, 2007; Trusty, Thompson, & Petrocelli, 2004; Zientek, Capraro, & Capraro, 2008), we report effect sizes for statistical results. Additionally, we performed independent samples t-tests to determine if any significant differences between the two sections of the course.

Second, we constructed a hierarchical linear regression model to provide explanatory power to trends in the preservice teachers' curriculum design for inquiry. The dependent or outcome variable was the post-adaptation inquiry scores of the preservice teachers' revised science lessons in the first and second reflective teaching assignments. In this regression model, 3 predictor variables were used: the inquiry score of the curriculum materials the preservice teachers initially used to develop their lesson, a composite variable for the types and frequencies of curriculum materials they used and adaptations they made, and a composite variable for self-efficacy and preferences for science teaching. These groups of variables are consistent with theoretical models of the teacher-curriculum relationship that foreground dynamic interactions teachers have with curriculum materials based on their own views and features of the curriculum materials themselves (Remillard, 2005). We used hierarchical regression model because the variables are added to the model one at a time such that the cumulative effect of independent variables on the outcome variable can be ascertained. This model met the requirements of linearity, independence, homoscedasticity, and normality (Osborne & Waters, 2002).

Results

In the sections that follow, we first provide descriptive statistics for the types and frequencies of science curriculum materials the preservice teachers used and the adaptations they made to them. Next, we present results that show how the preservice teachers' curriculum design efforts resulted in more inquiry-oriented planned science lessons and explore relationships between these variables. Finally, we present findings from hierarchical linear regression analyses to explore the influence of science curriculum materials and the preservice teachers' curriculum design decisions on the inquiry scores of their revised science lessons.

Preservice Teachers' Curriculum-Design Decisions

In this section I present results from the preservice teachers' first and second reflective teaching assignments (RT1 and RT2). In our first research question, we asked, "*how many and what types of curriculum materials do they use and adaptations do they make?*, ". We first discuss the types and frequencies of science curriculum materials the preservice teachers used and then the types and frequencies of adaptations they made to them.

Types and Frequencies of Curriculum Materials Used

Trends in the types and frequencies of curriculum materials used by the preservice teachers were similar across the two reflective teaching (RT) assignments. In both RT assignments, the preservice teachers predominantly used existing lesson plans and student worksheets in their science lessons. These results are presented in Figure 1 and Table 3.

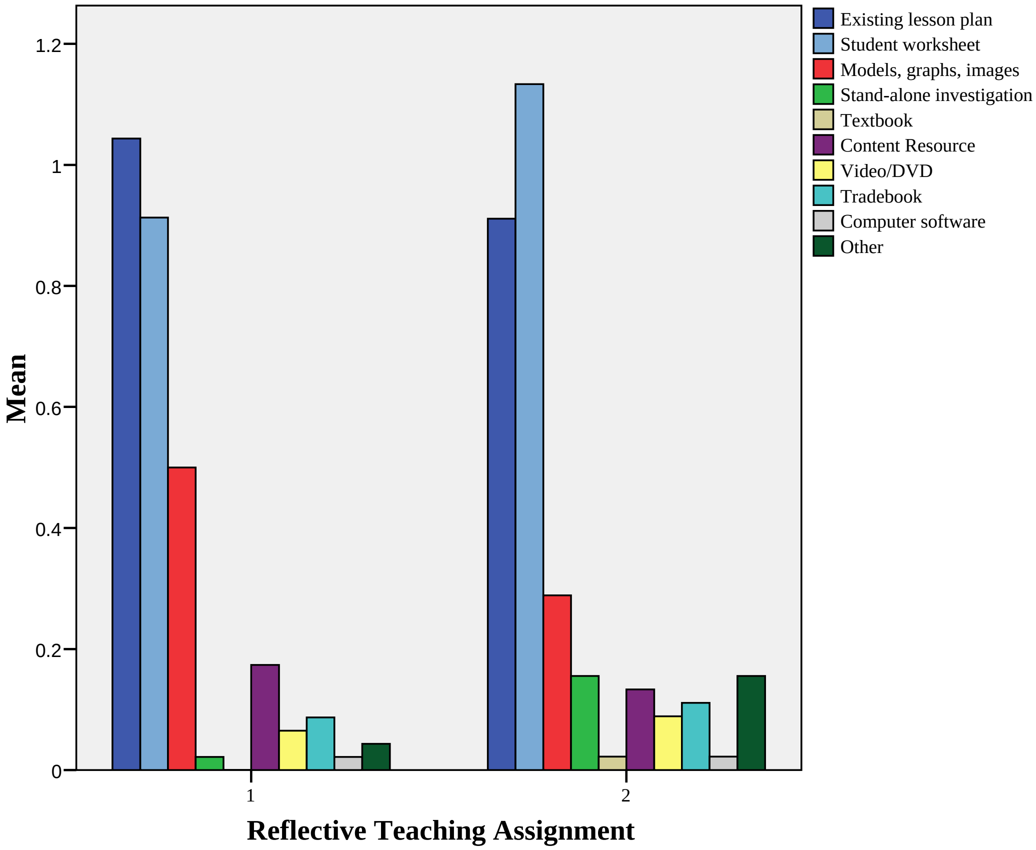

Figure 1. Mean Number of Curriculum Materials Used by Preservice Teachers in Reflective Teaching Assignments 1 and 2

Table 3

Frequencies and Percentages of Curriculum Materials Used by Preservice Teachers in Reflective Teaching Assignments 1 and 2

		Frequencies			
	RT	0	1	2	3 or more
Existing lesson plan	1	3 (6.5%)	38 (82.6%)	5 (10.9%)	-
	2	9 (20%)	31 (68.9%)	5 (11.1%)	-
Student worksheet	1	11 (23.9%)	28 (60.9%)	7 (15.2%)	-
	2	10 (22.2%)	24 (53.3%)	7 (15.6%)	4 (8.9%)
Models, graphs, images	1	35 (76.1%)	8 (17.4%)	3 (6.6%)	-
	2	39 (86.7%)	5 (11.1%)	1 (2.2%)	-
Stand-alone investigation	1	45 (97.8%)	1 (2.2%)	-	-
	2	38 (84.4%)	7 (15.6%)	-	-
Textbook	1	46 (100%)	-	-	-
	2	44 97.6%)	1 2.2%)	-	-

Content Resources	1	38 (82.6%)	8 (17.4%)	-	-
	2	39 (86.7%)	6 (13.3%)	-	-
Video/DVD	1	43 (93.5%)	3 (6.5%)	-	-
	2	41 (91.1%)	4 (8.9%)	-	-
Tradebook	1	42 (91.3%)	4 (8.7%)	-	-
	2	41 (91.1%)	3 (6.7%)	1 (2.2%)	-
Computer software	1	45 (97.8%)	1 (2.2%)	-	-
	2	44 (97.6%)	1 (2.2%)	-	-
Other	1	44 (95.7%)	2 (4.3%)	-	-
	2	38 (84.4%)	7 (15.6%)	-	-

In the first reflective teaching assignment, all but three of the preservice teachers, or 93.5%, used existing science lesson plans (M=1.04, SD=0.419). Five preservice teachers, or 10.9%, used more than one existing lesson plan to plan their science lessons. Also, over 76% of the preservice teachers used some form of student worksheet (M=0.91, SD=0.626). There was no statistically-significant difference between the mean number of existing lesson plans and student worksheets used by the preservice teachers, t(45) = 1.29, p = 0.22, d = 0.24. The next most frequently-used type of curriculum material was models, graphs, or images, which were used by just under 25% of the preservice teachers in RT 1 (M=0.5, SD = 1.38). The difference between the number of models, graphs, or images used by the preservice teachers and the number of existing lesson plans was statistically- significant, t(45) = 2.6, p = .013, d = 0.53, though not so for student worksheets, t(45) = -1.9, p = .055, d = 0.38. The remaining types of curriculum materials were used by less than 20% of the preservice teachers.

In the second reflective teaching assignment, only 80% of the preservice teachers used existing lesson plans (M=0.91, SD=.557), approximately 13% fewer than in RT1. However, 77.8% of the preservice teachers used student worksheets (M=1.13, SD=0.92), a similar percentage as in RT1. There was no statistically-significant difference between the number of preservice teachers who used existing lesson plans and those who used students worksheets in

RT2, t(45) = -1.7, *p* = .096, *d* = 0.29. As with RT1, the next most frequently-used type of curriculum material was models, graphs, or images, which were used by under 15% of the preservice teachers in RT 2 (M=0.29, SD = 1.82). The difference between number of models, graphs, or images used by the preservice teachers was significantly less than both the number of existing lesson plans, t(45) = 3.08, *p* = .004, *d* = 0.65, and student worksheets, t(45) = -3.4, *p* = .001, *d* = 0.78. The remaining types of curriculum materials were used by less than 10% of the preservice teachers.

Frequencies of curriculum materials used. In each of their reflective teaching assignments, the preservice teachers mobilized a number of existing curriculum materials to plan and develop their science lessons. An overview of the total number of unique curriculum materials they used in each reflective teaching assignment is presented in Figure 2.

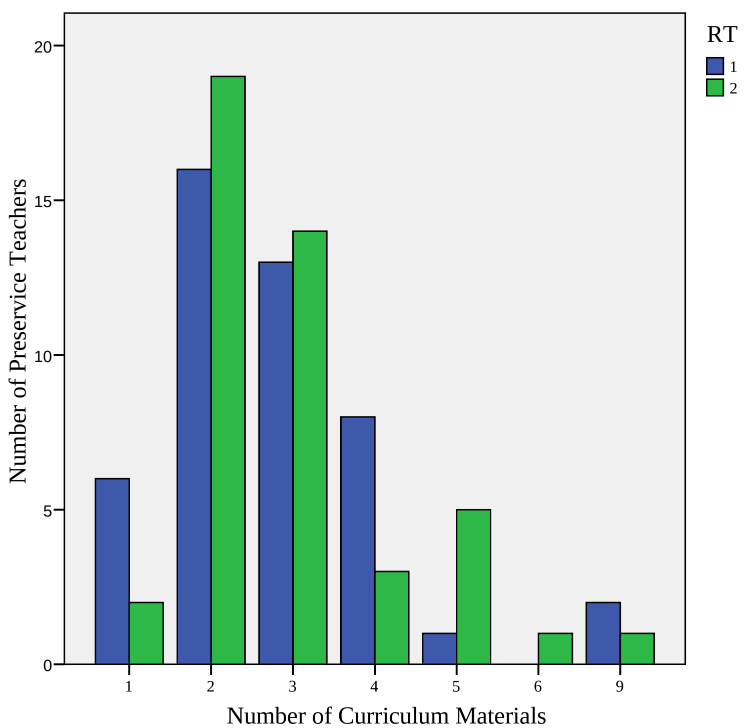

Figure 2. Frequencies of Curriculum Materials Used by Preservice Teachers in Reflective Teaching Assignments 1 and 2.

In the first reflective teaching assignment the preservice teachers used an average of 2.89 (SD = 1.668) unique curriculum materials to plan their science lessons. In the second RT assignment, the preservice teachers used an average of 2.96 (SD = 1.492) existing curriculum materials. Though the preservice teachers used slightly more curriculum materials in the second RT assignment, the difference between the number of curriculum materials used in RT assignments 1 and 2 was not statistically significant, $t(45) = -0.234$, $p = 0.816$, $d = 0.04$. Additionally, the number of curriculum materials used in RT1 and RT2 was only weakly and insignificantly correlated, $r(45) = .272$, $p = 0.071$, suggesting that the preservice teachers did not necessarily tend to use the same number of curriculum materials in their second RT assignment as in their first.

Types of curriculum materials used. In addition to analyzing the total number of curriculum materials the preservice teachers used, we also investigated the number of unique *types* of curriculum materials they used[1]. An overview of the number of types of unique curriculum materials they used in each assignment is presented in Figure 3.

[1] For example, a preservice teacher may have used four total curriculum materials to plan her lesson. However, if one was a lesson plan and the other three were student worksheets, she only used two unique types.

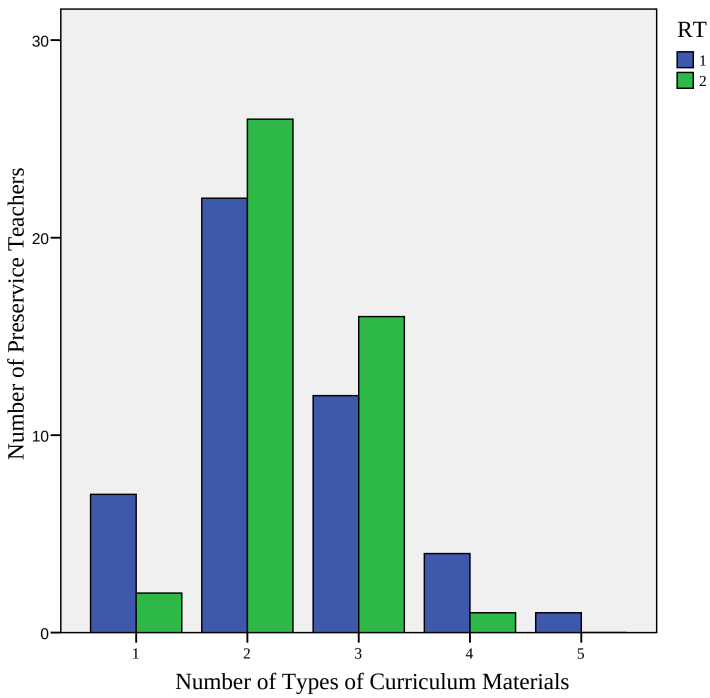

Figure 3. Number of Types of Curriculum Materials Used by Preservice Teachers in Reflective Teaching Assignments 1 and 2.

In the first RT assignment the preservice teachers used an average of 2.36 (SD = 0.933) unique types of curriculum materials to plan their science lessons. In the second RT assignment, the preservice teachers also used an average of 2.36 (SD = 0.609) types of existing curriculum materials. The mean number of types of curriculum materials they used was therefore the same in both RT assignments. As with the total number of curriculum materials previously, the number of types of curriculum materials used in RT1 and RT2 was weakly and insignificantly correlated, r(45) = .292, $p = 0.051$, suggesting that the preservice teachers did not necessarily tend to use the same number of types of curriculum materials in their second RT assignment as in their first.

Comparing Frequencies and Types of Curriculum Materials Used. The preservice teachers used a greater total number of curriculum materials than they did unique types of curriculum materials in both RT 1, $t(45) = -2.77$, $p = 0.008$, $d = 0.53$, and RT2, $t(44) = -3.01$, $p = .004$, $d = 0.39$. What this suggests is that preservice teachers often used more than one curricular resource of a particular type in a given RT assignment. For example, many preservice teachers used multiple student worksheets in a single lesson. Additionally, preservice teachers who used more curriculum materials also tended to use a greater number of types of curriculum materials, both in RT 1, $r(46) = .661$, $p < .001$, and RT2, $r(46) = .443$, $p = .002$. These relationships suggest that the more curriculum materials a preservice teacher used, the more likely he or she was to also use a greater variety of types of curriculum materials.

Summary. The preservice teachers predominantly used existing lesson plans and students worksheets in their curriculum design for inquiry. They tended to use roughly three distinct science curriculum materials for each reflective teaching assignment. However, they did not always use an equal number of different *types* of science curriculum materials, which suggests they often used more than one of the same type of curriculum material to plan a given lesson. Within each reflective teaching assignment, preservice teachers who used more science curriculum materials to plan their lessons also tended to use more types of science curriculum materials. However, across reflective teaching assignments 1 and 2, they did not necessarily use similar numbers or types of science curriculum materials.

In addition to mobilizing and using specific types and frequencies of curriculum materials, the preservice teachers also adapted them in particular ways. I next turn to their curricular adaptations.

Types and Frequencies if Adaptations Made

Recall from Chapter 3 that the preservice teachers' curricular adaptations were coded as insertions, deletions, substitutions, duplications, inversions, and relocations. Trends in the types and frequencies of adaptations made by the preservice teachers were similar across both RT assignments. In both assignments, the preservice teachers predominantly added, or inserted, new elements into existing science curriculum materials or substituted new elements for existing elements in the science curriculum materials they used. These results are presented in Figure 4 and Table 4.

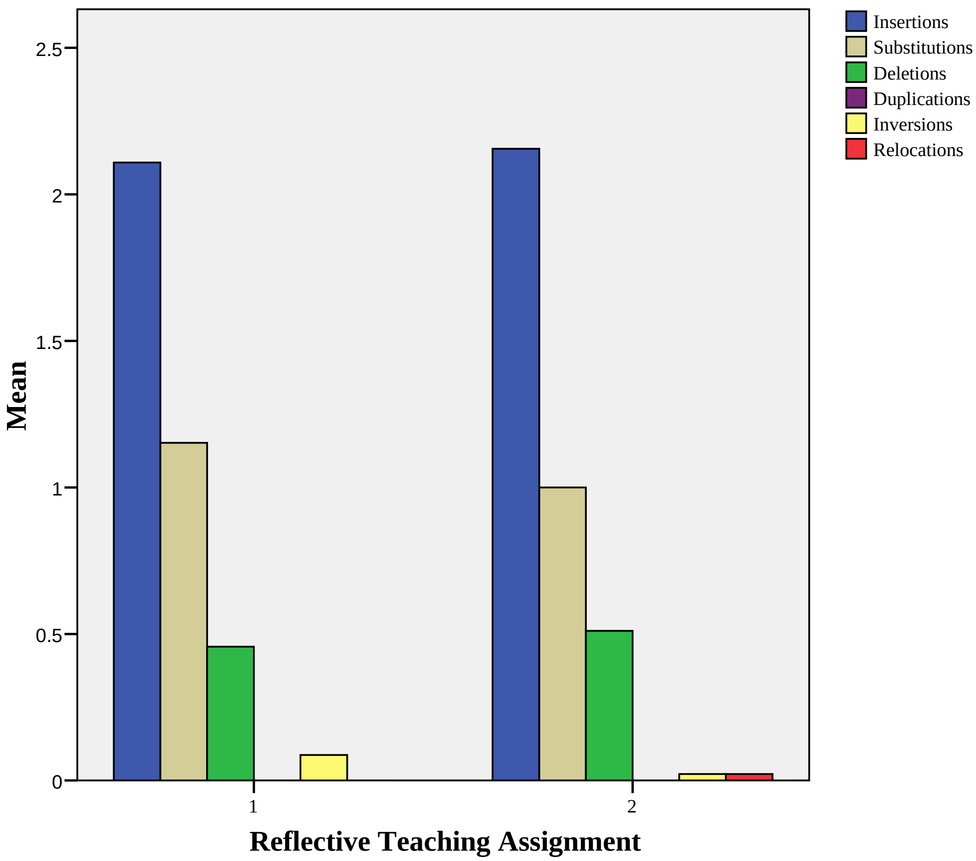

Figure 4. Mean Number of Adaptations Made by Preservice Teachers in Reflective Teaching Assignments 1 and 2

Table 4

Frequencies and Percentages of Adaptations Made by Preservice Teachers in Reflective Teaching Assignments (n_{RT1} = 46, n_{RT2}=45)

		Frequencies				
	RT	0	1	2	3	4 or more
Insertions	1	3 (6.5%)	15 (32.6%)	13 (28.3%)	6 (13.0%)	9 (19.6%)
	2	4 (8.9%)	10 (22.2%)	13 (28.9%)	12 (26.7%)	6 (13.3%)
Deletions	1	30 (65.2%)	12 (26.1%)	3 (6.5%)	1 (2.2%)	-
	2	29 (64.4%)	9 (20%)	7 (15.6%)	-	-
Substitutions	1	17 (37%)	10 (21.7%)	15 (32.6%)	3 (6.5%)	1 (2.2%)
	2	14 (31.3%)	21 (46.7%)	6 (13.3%)	4 (8.9%)	-
Duplications	1	46 (100%)	-	-	-	-
	2	45 (100%)	-	-	-	-
Inversions	1	43 (93.5%)	2 (4.3%)	1 (2.2%)	-	-
	2	44 (97.8%)	1 (2.2%)	-	-	-
Relocations	1	46 (100%)	-	-	-	-
	2	44 (97.8%)	1 (2.2%)	-	-	-

In the first RT assignment, all but three of the preservice teachers, or 93.5%, inserted new elements into the lesson plans they used, for a mean of 2.11 insertions per preservice teacher (SD = 1.34). They made significantly more insertions than any other type of adaptation, t(46) = 6.97, $p < .001$, $d = 0.79$. Also, 63% of the preservice teachers substituted new lesson elements for existing lesson elements in their lesson plans, for a mean of 1.15 substitutions per preservice teacher (SD = 1.07). This was significantly more than any other type of adaptation except insertions, t(46) = -3.74, $p = .001$, $d = 0.75$. Just over 35% of the preservice teachers deleted elements from their lessons, for a mean of 0.46 deletions per preservice teacher (SD = 0.72), which was significantly more than any other type of adaptation except insertions and substitutions, t(46) = 3.38, $p = .001$, $d = 0.65$. Only three teachers made inversions and none of the teachers made duplications or relocations.

In the second RT assignment, all but four of the preservice teachers, or 91.1%, inserted new elements into the lesson plans they used, for a mean of 2.16 insertions per preservice teacher (SD = 1.22). The preservice teachers made significantly more insertions than any other type of adaptation, t(45) = 4.55, $p < .001$, $d = 1.08$. Also, 68.9% of the preservice teachers substituted new lesson elements for existing lesson elements in their lesson plans, for a mean number of 1.0 substitutions per preservice teacher (SD = 0.91), which was significantly more than any other type of adaptation except insertions, t(45) = -3.1, $p = .003$, $d = 0.59$. Just over 35% of the preservice teachers deleted elements from their lessons, for a mean number of 0.51 deletions per preservice teacher (SD = 0.76), which was significantly more than any other type of adaptation except insertions and substitutions, t(45) = 4.17, $p < .001$, $d = 0.90$. Only one teacher made inversions and/or relocations, and no teachers made duplications.

In sum, the preservice teachers primarily inserted, or added, new elements into their RT lessons to make them more inquiry-oriented. To a lesser extent, they also substituted or deleted elements in the curriculum materials they used, through they rarely or never inverted, duplicated, or relocated existing lesson elements. What this suggests is that the preservice teachers were more likely to add or remove lesson elements than to rearrange existing lesson elements. However, to characterize the preservice teachers' curriculum design for inquiry, it is also necessary to analyze the frequencies of their adaptations, to which we turn next.

Frequencies of adaptations made to curriculum materials. An overview of the total number of unique adaptations the preservice teachers made in each assignment is presented in Figure 5.

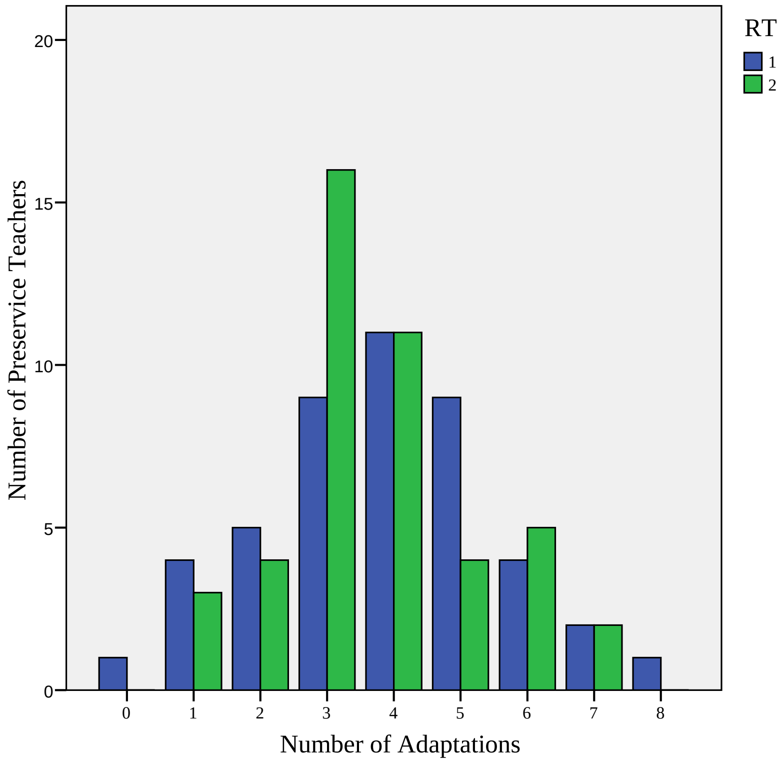

Figure 5. Frequencies of Adaptations Made by Preservice Teachers in Reflective Teaching Assignments 1 and 2.

In the first RT assignment the preservice teachers made an average of 3.78 (SD = 1.744) unique adaptations to the curriculum materials they used to plan their science lessons. In the second RT assignment, the preservice teachers made an average of 3.71 (SD = 1.487) adaptations. Though the preservice teachers made slightly more adaptations in their first reflective teaching assignment than the second, the difference was not statistically significant, $t(45) = 0.277$, $p = 0.78$, $d = 0.04$. However, the number of adaptations made in RT1 and RT2 was moderately correlated, $r(45) = .509$, $p < .001$. This suggests that the preservice teachers who made more adaptations in RT1 tended to also be the ones who made more adaptations in RT2, and vice versa.

Types of adaptations made to curriculum materials. In addition to analyzing the total number of adaptations the preservice teachers made, we also investigated the number of unique types of adaptations they made[2]. An overview of the number of types of unique adaptations they made in each assignment is presented in Figure 6.

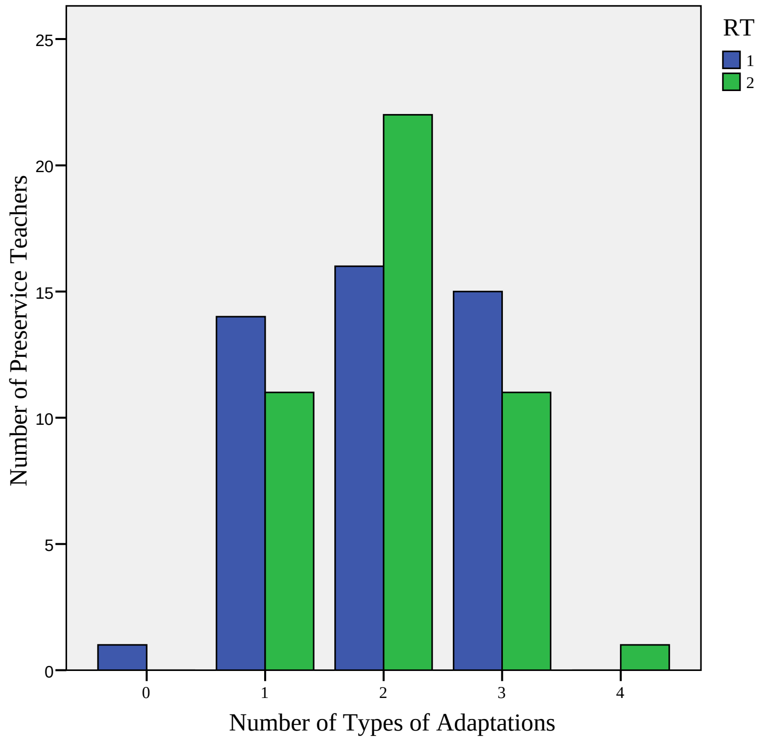

Figure.6. Number of Types of Adaptations Made by Preservice Teachers in Reflective Teaching Assignments 1 and 2.

In the first reflective teaching assignment the preservice teachers made an average of 1.96 (SD = .852) unique types of adaptations to the curriculum materials they used to plan their science lessons. In the second reflective teaching assignment, the preservice teachers made an average of 2.04 (SD = .767) unique types of adaptations. Though the preservice teachers made slightly more types of adaptations in their second reflective teaching assignment than the first, the difference was not statistically significant, $t(45) = -0.628$, $p = 0.533$, $d = 0.10$. However, the

[2] For example, a preservice teacher may have made three total adaptations to plan her lesson. However, if one was a deletion and the other two were insertions, she only made two unique types.

number of types of adaptations made in RT1 and RT2 was weakly correlated, $r(45) = .316$, $p = 0.034$. This suggests that the preservice teachers who made more types of adaptations in RT1 tended to also be the ones who made more types of adaptations in RT2, and vice versa.

Overall, the preservice teachers made a greater total number of adaptations than unique types of adaptations to the curriculum materials they used, both in RT 1, $t(45) = -9.40$, $p < 0.001$, $d = 1.34$, and RT2, $t(44) = -9.13$, $p < 0.001$, $d = 1.41$. What this suggests is that preservice teachers often made more than one adaptation of a particular type in a given RT assignment. Additionally, preservice teachers who made more adaptations also tended to make more types of adaptations, both in RT 1, $r(46) = .678$, $p < .001$, and RT2, $r(46) = .569$, $p < .001$. These correlations suggest that the more adaptations a preservice teacher made, the more likely he or she was to also make a greater variety of types adaptations.

Summary. The preservice teachers predominantly added new elements to the science lesson plans they used to plan their science lessons. They tended to make between three and four distinct adaptations in each reflective teaching assignment. However, they did not tend to make an equal number of different types of adaptations, which suggests they often made more than of one type of adaptation to the lesson plans they used to plan their science lessons. For example, the preservice teachers often inserted multiple new elements into their lesson plans. Within each reflective assignment, preservice teachers who made more adaptations also tended to make more types of adaptations. Across RT assignments, the preservice teachers who made more adaptations and more types of adaptations in RT1 tended to do so again in RT2.

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Inquiry Orientation of Pre- and Post-adaptation Curriculum Materials

In research question 2, we asked, "*how inquiry-oriented are their lessons before and after adaptation?*". In order to ascertain whether or not the preservice teachers developed more inquiry-oriented science lessons through their curriculum design decisions, we also scored their science lessons for elements of inquiry before and after adaptation. Across the two reflective teaching assignments the preservice teachers completed, trends in the inquiry scores of their initial curriculum materials, their final, revised lessons, and the difference between the two were consistent. In both reflective teaching assignments, the preservice teachers were able to modify existing science curriculum materials to make them more inquiry-oriented. An overview of these findings is shown in Figure 7.

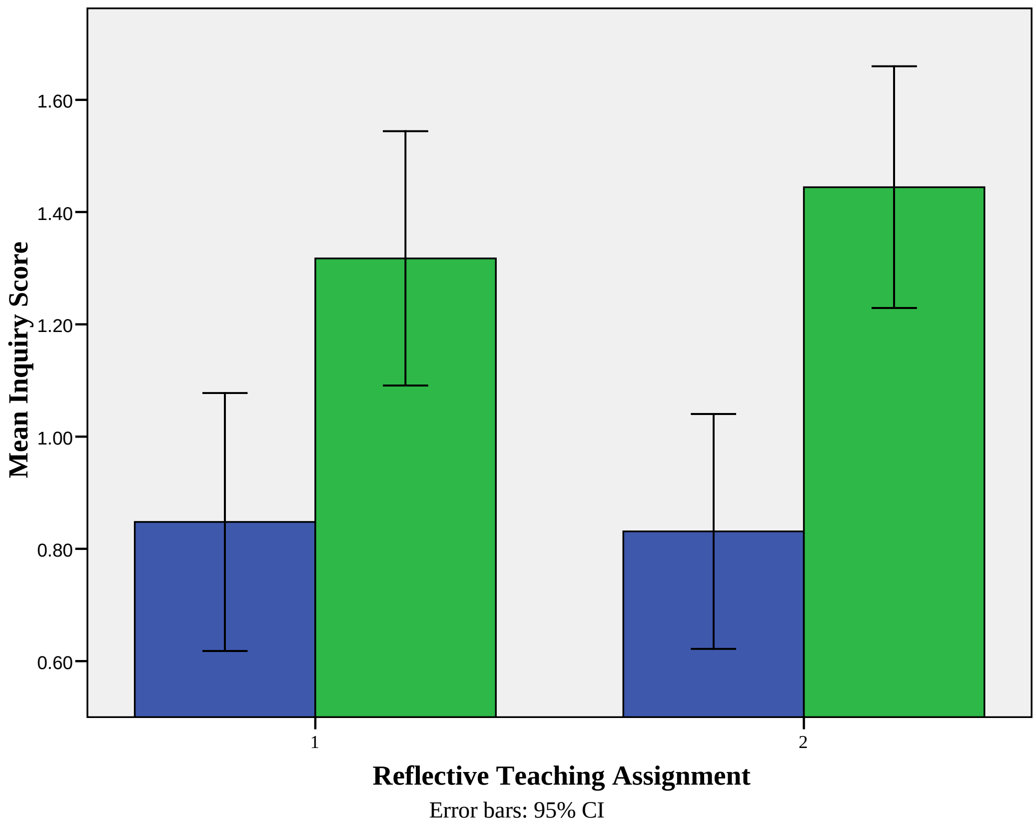

Figure 7. Pre- and Post-adaptation Inquiry Scores of Preservice Teachers' Lesson Plans in Reflective Teaching Assignments 1 and 2.

In the next three sections, we describe the inquiry scores of the curriculum materials the preservice teachers used, the post-adaptation inquiry scores of their modified lessons, and changes in their inquiry scores.

Inquiry scores of initial curriculum materials

In both reflective teaching assignments, the curriculum materials the preservice teachers used to plan and develop their lessons were not highly inquiry-oriented ($M < 1$ on a 4-point scale)[3]. In the first reflective teaching assignment, the curriculum materials they used had an average inquiry score of 0.85 ($SD = 0.77$) while those they used in the second reflective teaching assignment were even slightly less inquiry-oriented than those they used in the first ($M = 0.83$, $SD = 0.70$). However, the difference between these inquiry scores was not statistically significant, $t(45) = 0.239$, $p = 0.79$, $d = 0.05$, suggesting that the curriculum materials the preservice teachers initially used in both reflective teaching assignments, on average, were similarly inquiry-oriented.

Inquiry scores of revised lessons

In both reflective teaching assignments, the preservice teachers modified these existing curriculum materials to construct revised science lessons that were more inquiry-oriented than the original ones. In the first reflective teaching assignment, the average inquiry score for the preservice teachers' revised lessons was 1.32 ($SD = 0.76$) and, in the second reflective teaching assignment, the mean inquiry score of the preservice teachers' revised lessons was 1.44 ($SD = 0.72$). While the inquiry scores of the preservice teachers' revised lessons were slightly higher in the second reflective teaching assignment, this difference was not statistically significant, $t(45) =$

[3] These inquiry scores represent a mean score for all five essential elements of inquiry (NSES, 2000) in any given science lesson or group of science curriculum materials. Many lessons were particularly inquiry-oriented for one or two elements of inquiry but not for the remainder, suggesting individual lessons may emphasize a subset of inquiry practices rather than all of them.

-0.757, p = 0.11, d = 0.14. This suggests that the preservice teachers were equally able to effectively adapt science lessons they used in both reflective teaching assignments to make them more inquiry-oriented.

Change in inquiry scores

In both reflective teaching assignments, the preservice teachers' adaptations either increased or had no impact on the inquiry scores of the science lesson plans they used. In the first reflective teaching assignment, the average change in inquiry score was 0.46 (SD = 0.43) a significant increase, t(46) = -7.5, p < .001, d = 0.61. Similarly, in the second reflective teaching assignment, the average change in inquiry score was 0.61 (SD = 0.61), also a statistically-significant increase, t(45) = -6.75, p < 0.001, d = 0.87. There was no statistically-significant difference in the change in inquiry scores between RT1 and RT2, t(45) = -1.30, p = .20, d = 0.17. In only three cases across both RT assignments did their adaptations result in less inquiry-oriented lessons than those with which they began.

Results also suggest that the preservice teachers' capacities to make their lessons more inquiry-oriented were independent across the two reflective teaching assignments. Preservice teachers who had higher post-adaptation inquiry scores for their RT1 lessons were equally as likely as preservice teachers who had lower post-adaptation inquiry scores on the RT1 lessons to have higher post-adaptation inquiry scores on their RT2 lessons, r(45) = 0.241, p = .11. Or, in other words, a preservice teacher whose revised lesson in RT1 was less inquiry-oriented was equally as likely to have a RT2 lesson that was more inquiry-oriented. The overall change in inquiry scores between the first and second reflective teaching assignments were not significantly correlated, r(45) = 0.06, p = 0.71. This finding suggests that the preservice teachers who significantly increased the inquiry scores of their science lesson in one reflective assignment did not necessarily do so in the other reflective assignment, and vice versa. Or, in other words, a preservice teacher who did not increase the inquiry score of her RT1 lesson was no less likely than a preservice teacher who had to significantly increase the inquiry score of her RT2 lesson.

Finally, in their reflective teaching assignments, the preservice teachers were also asked to assess how inquiry-oriented they felt their revised science lessons were. Response options for this question included 'very', 'somewhat', 'not very', and 'not at all' inquiry-oriented. Differences between the preservice teachers' self-assessment of the inquiry-orientation of their revised lessons and the post-adaptation inquiry scores were not statistically-significant, either in RT1, $F(3, 42) = 1.71$, $p = .180$, $\omega^2 = 0.09$, or RT2, $F(2, 42) = 3.00$, $p = .061$, $\omega^2 = 0.21$. This finding shows that the preservice teachers were able to accurately assess the inquiry-orientation of their revised lessons in both reflective teaching assignments.

Summary

This analysis suggests that across the first and second reflective teaching assignments, there was little difference between the inquiry-orientation of the existing curriculum materials the preservice teachers used and adapted or between their revised lesson plans. In both assignments, they were able to make adaptations that did result in statistically-significant increases in the overall inquiry-orientation of their lessons. However, their abilities to do so were largely independent across reflective teaching assignments. Additionally, the preservice teachers were able to accurately assess how inquiry-oriented their lessons were in both reflective teaching assignments.

Effect of Curriculum Materials and Preservice Teachers' Curriculum Design Decisions on Inquiry Scores and Change in Inquiry Scores

Finally, in research question 3, we asked, "*what factors explain their ability to make existing science curriculum materials more inquiry-oriented?*". We created a hierarchical linear regression model to determine whether there were relationships between the preservice teachers' curriculum design decisions and the inquiry scores of their revised lesson plans. We used hierarchical multiple regression because the predictor variables are added to the model one at a time such that the cumulative effect of these variables on the outcome variable can be ascertained. The primary purpose of this analysis is to provide a degree of statistical explanatory power for how the types and frequencies of curriculum materials the preservice teacher used, the types and frequencies and adaptations they made, as well as the inquiry score of the initial lesson plans and/or curriculum materials they used affected the inquiry scores of their revised lessons.

Description of Regression Model

We used three predictor variables in the regression model, each of which was added to the model in stepwise fashion. For the first and third predictor variables, we used composite, calculated scores, one for the curriculum materials the preservice teachers used and the other for the adaptations they made[4]. These individual scores were calculated by averaging the total number and total number of types of both curriculum materials and adaptations. As such, they did not directly reflect real-world phenomena but are composite, proxy measures of the preservice teachers' overall mobilization and adaptation of curriculum materials. For the second predictor variable, we include the inquiry scores of the original lesson plans and/or curriculum materials the preservice teachers used to engage in curriculum planning. This provides a measure of how inquiry-based these curriculum materials were to begin with. These three variables are consistent with theoretical models of the teacher-curriculum relationship that

[4] Using these individual variables (i.e., # of curriculum materials and # of types of curriculum materials, # of adaptations and # of types of adaptations) directly in the regression model would not have been appropriate since, as shown previously, each of these sets of two variables were significantly correlated.

foreground dynamic interactions teachers have with curriculum materials based on their own views and features of the curriculum materials themselves (Brown, in press; Remillard, 2005).

It would have been preferable to include each of the coded variables for types of curriculum materials and types of adaptations (from Tables 1 and 2) into this regression model rather than the composite, calculated scores. However, this would have resulted in 15-20 predictor variables. Due to the relatively small sample size of preservice teachers, the use of so many independent variables would not have been appropriate. In order to maintain statistical power, many quantitative researchers suggest erring on the side of caution in decisions about the number of predictor variables to include in multiple regression models. Conflicting guidelines persist in the literature, particularly in the use of regression models for explanation vs. prediction (Kelley & Maxwell, 2003; Knofczynski & Mundform, 2008; Maxwell, 2000; Milton, 1986; Sawyer, 1982). For example, many rules of thumb exist regarding the number of predictor variables to use in a regression model in light of sample size, ranging from less than 10:1 to 400:1 (see (Maxwell, 2000) and (Green, 1991) for a more through review of these rules of thumb).

Milton (1986) provides a formula for calculating effective sample size for multiple regression, $n = k + 1 + [t^2(1 - R^2)/ \Delta r_j^2]$. This formula for sample size (n) is a function of the number of predictor variables (k), desired t-statistic (t^2), anticipated coefficient of determination (R^2), and the minimum additive influence on r^2 (Δr_j^2)of the final predictor variable added to the model. In my regression, I employ 3 predictors ($k = 3$), need to achieve the commonly-accepted significance level of 0.05 ($t^2 = 2$), anticipate a minimum R^2 of 0.2 (40%), and expect that the final predictor added to my model and contributing at least 3% of additional explained variance be significant at the 0.05 level ($\Delta r_j^2 = 0.03$). Using these values, Milton's (1986) formula suggests a necessary sample size of n = 44. Given our sample size of 46, we therefore employ three predictor variables, two of which are composite, calculated measures, in the regression model.

In the regression model below, the three independent variables are added stepwise to determine the degree to which they each affect the outcome variable sequentially. The order of addition to the model is based in theory as well as a practical understanding of the curriculum design process in this study. First, the preservice teachers mobilized curriculum materials to use in planning their two reflective teaching assignments. Therefore, the composite variable for 'curriculum materials' is first to be added to the model. Second, these curriculum materials, once selected and mobilized, afforded a certain level of inquiry through their design. Thus, the second predictor variable added to the model is 'inquiry pre', or the inquiry score of the lesson plans and curriculum materials the preservice teachers used. Finally, third, the preservice teachers made adaptations to these lessons to varying degrees. The last predictor variable added to the model is therefore the composite variable for 'adaptations'.

Finally, in Table 5 below, we present the unstandardized regression coefficients, significance levels for each of the independent variables, as well as the coefficient of determination (R^2) and change in R^2. These statistics are included for both the first and second reflective teaching assignments the preservice teachers completed.

Regression Analysis Results

For the regression model, we used the inquiry scores of the preservice teachers' revised lessons as the outcome variable. Table 5 includes the results of this analysis.

Table 5

Effect of Teachers' Curriculum Materials' Use on Post-Adaptation Inquiry Scores of Lessons (n_{RT1}=46, n_{RT2}=45)

	RT1			RT2		
Independent Variables	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Curriculum Materials	-0.117	0.005	-0.006	0.312*	0.175	0.100
Inquiry Pre	-	0.838***	0.861***	-	0.574***	0.655***
Adaptations	-	-	0.093	-		0.196*
Constant	1.622***	0.595*	0.334***	0.615	0.504	0.071
R^2	0.032	0.718***	0.739***	0.161*	0.44***	0.470
Change in R^2	-	0.686***	0.021	-	0.279***	0.066*

*p < 0.05, ***p < 0.001

The first independent variable added to the model was the composite variable for the curriculum materials the preservice teachers used (Model 1). In the first reflective teaching assignment, curriculum materials was not a statistically-significant predictor for the inquiry scores of their revised lessons, F(1,44) = 1.475, p = 0.231, and explained only 3.2% of the variance of the post-adaptation inquiry scores of the preservice teachers' lessons. However, in the second reflective teaching assignment, curriculum materials was a statistically-significant predictor for the inquiry scores of their revised lessons, F(2,43) = 8.274, p = 0.006 and accounted for 16.1% of the variance of the post-adaptation inquiry scores of the preservice teachers' lessons. This suggests that the preservice teachers' decisions about the types and frequencies of curriculum materials to use in the reflective teaching assignment did not significantly affect the post-adaptation inquiry scores of their RT1 lessons, but did in their RT2 lessons.

The second independent variable added to the model was the inquiry score of the lesson plans and curriculum materials the preservice teachers used (Model 2). In the first reflective teaching assignment, the addition of the pre-adaptation inquiry scores of the curriculum materials the preservice teachers used were statistically-significant for the inquiry scores of their revised lessons, $F(2,43) = 54.86$, $p < 0.001$. Alone, 'inquiry pre', or the pre-adaptation inquiry score of the preservice teachers' lessons, explained 68.6% of the variance in post-adaptation inquiry scores of their revised lessons. Combined with the types and frequencies of curriculum materials the preservice teachers used, the two predictor variables in Model 2 accounted for a combined 71.8% of the variance in the post-adaptation inquiry scores of the preservice teachers' lessons. In the second reflective teaching assignment, this trend was repeated, though to a lesser extent. In RT2, pre-adaptation inquiry scores were statistically-significant for the inquiry scores of their revised lessons, $F(2,42) = 16.528$, $p < 0.001$. Alone, 'inquiry pre' accounted for 27.9% of the variance in post-adaptation inquiry scores of the revised lessons. Combined with the types and frequencies of curriculum materials the preservice teachers used, the two predictor variables in Model 2 accounted for a combined 44% of the variance in the post-adaptation inquiry scores of the preservice teachers' lessons. This suggests that how inquiry-oriented the curriculum materials were that preservice teachers used had a highly significant effect on how inquiry-oriented their revised lessons were, though to a lesser extent in RT2 than RT1.

The third and final independent variable added to the model was the composite variable for the preservice teachers' adaptations (Model 3). In the first reflective teaching assignment, the addition of adaptations to the model was statistically-significant for the inquiry scores of their revised lessons, $F(3,42) = 39.65$, $p < 0.001$. Adaptations explained 2.1% of the variance in post-adaptation inquiry scores of the preservice teachers' revised lessons while, combined, the three predictor variables accounted for a combined 73.9% of the variance in the post-adaptation inquiry scores of the preservice teachers' revised lessons. In the second reflective teaching assignment, the addition of adaptations was statistically-significant for the inquiry scores of their revised lessons, $F(3.41) = 14.02$, $p < 0.001$. Adaptations explained 6.6% of the variance in post-adaptation inquiry scores of the preservice teachers' revised lessons while, combined, the three predictor variables accounted for a combined 47% of the variance in the post-adaptation inquiry scores of the preservice teachers' revised lessons. This suggests that the adaptations the preservice teachers made did not alone have significant affects on how inquiry-oriented their revised lessons were in RT1, but did so in RT2.

In summary, the regression analysis for the post-adaptation scores of the preservice teacher's lessons indicate that the singlemost significant determinant was the inquiry scores of the lesson plans and/or curriculum materials they began with. In RT1, neither of the other two predictor variables, curriculum materials and adaptations, were significant contributors to explanations of the variance of post-adaptation inquiry scores of the preservice teachers' lessons. However, in RT2, both were significant. Additionally, in RT2, the explanatory power of the pre-adaptation inquiry scores, as well as the regression model overall, decreased substantially. This suggests that predictor variables *not* included in the regression model became much more significant influences on how inquiry-oriented the preservice teachers' revised lessons were.

Summary of Results

We have presented findings from the two reflective teaching assignments completed by all preservice teachers in both sections of the undergraduate elementary science teaching methods course. These findings show that the preservice teacher predominantly used the most common forms of curriculum materials – lesson plans and various forms of student worksheets. They also show that they predominantly added or substituted new elements into these lesson plans. The preservice teachers' adaptations did result in more inquiry-oriented lessons.

However, as shown in the results of regression analysis, the inquiry scores were highly influenced by how inquiry-based the lesson plans were that the preservice teachers used. Each of these trends was consistent in both reflective teaching assignments.

Synthesis and Discussion

Findings from this research inform and extend a small but growing body of research focused on preservice elementary teachers and curriculum materials. These studies have made important contributions to the field's understanding of how preservice elementary teachers evaluate existing science curriculum materials. For example, existing research has illustrated those criteria that preservice elementary teachers tend to emphasize, such as hands-on science and making science relevant to students' lives, in their critique of science curriculum materials (Davis, 2006; Dietz & Davis, in press; Forbes & Davis, 2008; Schwarz et al., 2008). However, the process by which preservice teachers adapt their curriculum materials based on these critiques remains unexplored. Findings presented here extend this research by illustrating preservice elementary teachers' curriculum design decision-making that both precedes and follows their critique of science curriculum materials when they engage in curriculum design for inquiry.

Preservice Teachers' Mobilization and Adaptation of Science Curriculum Materials

The preservice teachers primarily used existing lesson plans and student worksheets in their planned science lessons. This suggests that the preservice teachers largely relied on the curriculum materials they had in their placement classrooms. In many ways this is not surprising given the need for them to teach their placement classroom's curriculum. However, it does suggest that these preservice teachers, like practicing elementary teachers, tend to use existing curriculum materials when available rather than engaging in all-out curriculum (Forbes & Davis, 2007; Grossman & Thompson, 2004; Kauffman et al., 2002). Because the preservice teachers did adapt the curriculum materials they mobilized, the process of curriculum design is indicative of *invention* (Remillard, 1999) or *adaptation* and *improvisation* (Brown, 2002). However, the preservice teachers largely mobilized and adapted existing lesson plans rather than mobilizing a wide variety of other curriculum materials around which to develop new lesson plans. To draw on the model of teachers' curriculum materials use from Figure 2.1, this process represents *focused improvisation* rather than *distributed improvisation*.

The picture of the preservice teachers' curriculum mobilization that begins to emerge is one that is highly lesson-dependent. More specifically, these findings suggest that the curriculum materials the preservice teachers used drove their planned instruction. This process contrasts with, for example, mobilizing appropriate curricular resources from a variety of sources to best support students to attain specified goals for learning. Additional evidence from the study supports this claim. Recall, for example, that there were no statistically-significant relationships between the number or types of curriculum materials the preservice teachers used across the two assignments. This finding indicates that the same preservice teacher tended to use very different types and frequencies of curriculum materials for each of his or her lessons. This is an important finding that not only illustrates the process by which preservice elementary teachers adapt science curriculum materials, but specifically that these curriculum materials play a critical role in defining the conceptual space within which teachers evaluate and adapt them in light of their ideas about inquiry.

These findings also add to existing research by showing how preservice teachers actually adapt curriculum materials based on their critiques and evaluations. Specifically, these findings illustrate the types and frequencies of adaptations that the preservice teachers made in curriculum design for inquiry. The preservice teachers largely added, deleted, or substituted elements in the lesson plans and curriculum materials they used. They did not rearrange existing lesson elements (relocations, translocations, inversions). Also, some tended to make more adaptations than others. There were moderate to strong, statistically-significant correlations between the types and frequencies of preservice teachers' adaptations across the two RT assignments. This suggests that preservice teachers who tended to make more adaptations in RT1 also tended to do so in RT2, and vice versa. This contrasts with findings for curriculum materials mobilization, for which these relationships across RT assignments did not similarly exist.

Preservice Elementary Teachers and Inquiry

These findings also shed light on how preservice elementary teachers engage in inquiry-oriented teaching practice. Many previous studies have shown that preservice teachers struggle to translate their ideas into science teaching practice (Bryan & Abell, 1999; Crawford, 1999; Southerland & Gess-Newsome, 1999; Zembal-Saul, Blumenfeld, & Krajcik, 2000). However, as shown in the results here, the preservice teachers were able to adapt their lessons to make them more inquiry-based in both reflective teaching assignments. This finding does show that the preservice teachers were able to engage in curriculum design practice to better support inquiry-based science instruction, reinforcing findings from other studies (Schwarz et al., 2008). These results also support those from a select few other studies that suggest preservice teachers can learn to engage in more inquiry-based science teaching practices more generally (Crawford, 1999, 2007).

A large body of research has also outlined how preservice teachers often hold views of inquiry and inquiry-based teaching and learning that are inconsistent with those advocated in science education reform (Bryan, 2003; Gess-Newsome, 2002; Howes, 2002; Windschitl, 2003, 2004). While this study did not directly characterize the preservice teachers' conceptions of inquiry, there is evidence that the preservice teachers were able to accurately assess how inquiry-based their lesson plans were. Recall that the inquiry scores of the preservice teachers' revised lesson plans were compared to the inquiry scores they self-assigned their lessons in the lesson plan rationale documents. There were no statistically-significant differences between these scores in either reflective teaching assignment, suggesting that the preservice teachers self-assessed their lesson plans similarly to the authors. This finding suggests that, at least at a general level, the preservice teachers' conceptions of inquiry were largely consistent with those of the authors and those promoted in the methods course.

Despite the increasing emphasis on the important role teachers play in critiquing and adapting curriculum materials, a tension still exists between teachers' curricular decision-making and intentions of the curriculum developers. As discussed earlier, past curriculum development efforts have sought to minimize the influence of the 'teacher effect' on curriculum enactment, thus promoting enactment with fidelity (Nye, Hedges, & Konstantopoulos, 2004). Indeed, viewed through the eyes of curriculum developers and science education researchers, teachers' adaptations can vary in quality (Collopy, 2003; Pintó, 2004; Remillard, 1999; Schneider, Krajcik, & Blumenfeld, 2005). However, it is important to note that here, in only three out of the 93 lessons analyzed in this study, did the preservice teachers' adaptations actually make their lessons less inquiry-oriented than those with which they began. In some ways, this finding contrasts with a reasonable assumption that preservice teachers, due to their lack of expertise, might be most likely to unintentionally develop lessons that are less effective. Rather, as shown in the regression model, the inquiry-ness of the curriculum materials they used was the biggest influence on the inquiry score of the preservice teachers' revised lessons. What these findings suggest is that the preservice teachers are unlikely to decrease the effectiveness of existing science lessons through their curriculum design decisions.

Implications and Conclusion

Results from this research further inform science teacher education and science curriculum development. First, this study has important implications for efforts in teacher education to support preservice teachers' development of pedagogical design capacity for inquiry. The findings presented here provide science teacher educators with insight into the types of science curriculum materials preservice teachers utilize, the ways in which they modify them, and how these adaptations lead to an increasing emphasis on inquiry in the science lessons they plan. These findings can help science teacher educators design effective instructional strategies in science methods courses and university-based elements of the teacher education programs. Future research should investigate the impact of specific instructional strategies and learning opportunities that best promote preservice elementary teachers' curriculum design decision-making for inquiry.

However, field experiences are also critical components of teacher education programs as they provide preservice teachers with opportunities to develop frameworks within and through which future learning can occur (Zembal-Saul, Blumenfeld, & Krajcik, 2000). Previous research has shown that effective field experiences are long-term and stable, involve the careful selection of cooperating teachers, and are tightly integrated with methods courses that promote reflective, intellectual, and professional teaching practice (Sim, 2006; Zembal, Starr, & Krajcik, 1999). Findings from this study also inform efforts to more fully integrate university-based components with school-based field experiences by providing preservice teachers with opportunities to use science curriculum materials in authentic ways and to put their professed models of inquiry to use through curriculum design for inquiry.

This research also helps curriculum developers design science curriculum materials that meet the needs of elementary teachers at this early stage along the teacher professional continuum. While a growing number of studies show that teachers often adapt curriculum materials rather than using them 'as-is', other studies have shown that novice teachers rely heavily on curriculum materials they use (e.g., Grossman & Thompson, 2004). Findings from this study indicate that the fear of teachers' unproductive adaptation of science curriculum materials, and the prospect of these adaptations resulting in 'lethal mutations' that negatively impact student learning, are perhaps exaggerated. By design inquiry-based science curriculum materials, curriculum developers are insuring that the curriculum materials themselves still determine, in large part, how inquiry-based the lessons are even if teachers adapt them. If the goal remains to engage students in inquiry in the classroom, these findings support an argument for the continued emphasis on inquiry in newly-developed science curriculum materials.

By embracing teachers' adaptation of curriculum materials, curriculum developers can take steps to actively support teachers' use of science curriculum materials by not only making them inquiry-based, but also flexibly-adaptive and educative for teachers (Ball & Cohen, 1996; Davis & Krajcik, 2005; Fishman & Krajcik, 2003; Schwartz, Lin, Brophy, & Bransford, 1999;

Squire, MaKinster, Barnett, Luehmann, & Barab, 2003). The development of such curriculum materials requires a thorough understanding of those to whom such materials are meant to be educative for and by whom they are meant to be adapted. However, there is still little research that informs our understanding of how teachers use these educative features of curriculum materials (Davis & Krajcik, 2005). By better understanding how preservice elementary teachers mobilize, adapt, and enact science curriculum materials in light of their professed models of inquiry, these curriculum materials can be better designed to simultaneously support their use and teacher learning.

The findings presented here shed important light on the process by which preservice elementary teachers engage in curriculum design for inquiry. However, this research has generated additional questions for future research. First, to fully understand the process of curriculum design, it is also important to understand how the degree to which the enacted lessons are inquiry-based and consistent with planned lessons. Future research on preservice teachers' use of curriculum materials should also characterize how these lessons actually play out in elementary classrooms. Second, such research should span longer periods of time. Because teachers' capacity for pedagogical design evolves over time, so too does their curriculum design practice. Future research should investigate the ways in which elementary teachers' curriculum design for inquiry evolves at stages along the teacher professional continuum, as well as in light of characteristics of their curriculum materials and professional contexts. Such research will also help in promoting teachers' development of pedagogical design capacity through preservice and inservice teacher education, as well as educative curriculum materials.

References

AAAS, American Association for the Advancement of Science (1993). *Benchmarks for Science Literacy, Project 2061*. New York: Oxford University Press.

Abell, S.K. (2007). Research on science teacher knowledge. In S.K. Abell & N.G. Lederman (Eds). *Handbook of research on science education*. (pp. 1105-1149). Mahwah, NJ: Lawrence Erlbaum.

Abell, S.K., Bryan, L.A., & Anderson, M.A. (1998). Investigating preservice elementary science teacher reflective thinking using integrated media cased-based instruction in elementary science teacher preparation. *Science Education, 82*(3), 491-509.

Ball, D. L. & Cohen, D. K. (1996). Reform by the book: What is—or might be—the role of curriculum materials in teacher learning and instructional reform? *Educational Researcher, 25*(9), 6-8, 14.

Bodzin, A.M. & Beerer, K.M. (2003). Promoting inquiry-based science instructon: The validation of the science teacher inquiry rubric (STIR). *Journal of Elementary Science Education, 15*(2), 39-49.

Brown, M. (2002). Teaching by Design: Understanding the Intersection between Teacher Practice and the Design of Curricular Innovations.

Brown, M. (in press). Toward a theory of curriculum design and use: Understanding the teacher-tool relationship. In B. Herbel-Eisenman J. Remillard, and G. Lloyd (Eds). *Teachers' use of mathematics curriculum materials: Research perspectives on the relationship between teachers and curriculum*. (pp.

Bryan, L.A. (2003). Nestedness of beliefs: Examining a prospective elementary teacher's belief systems about science teaching and learning. *Journal of Research in Science Teaching, 40*(9), 835-868.

Bryan, L.A. & Abell, S.K. (1999). Development of professional knowledge in learning to teach elementary science. *Journal of Research in Science Teaching, 36*(2), 121-139.

Chi, M. (1997). Quantifying qualitative analyses of verbal data: A practical guide. *The Journal of the Learning Sciences, 6*(3), 271-315.

Collopy, R. (2003). Curriculum materials as a professional development tool: How a mathmatics textbook affected two teachers' learning. *The Elementary School Journal, 103*(3), 287-311.

Crawford, B. (1999). Is it realistic to expect a preservice teacher to create an inquiry-based classroom? *Journal of Science Teacher Education, 10*(3), 175-194.

Crawford, B. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching, 44*(4), 613-642.

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research, 76*(4), 607-651.

Davis, E.A. (2006). Preservice elementary teachers' critique of instructional materials for science. *Science Education, 90*(2), 348-375.

Davis, E.A. & Krajcik, J. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher, 34*(3), 3-14.

DeBoer, G.E. (1991). *A History of Ideas in Science Education: Implications for Practice*. New York: Teachers College Press.

Dietz, C. & Davis, E. A. (in press). Preservice elementary teachers' reflection on narrative images of inquiry. *Journal of Science Teacher Education*.

Drake, C. & Sherin, M. G. (2006). Practicing change: Curriculum adaptation and teacher narrative in the context of mathematics education reform. *Curriculum Inquiry, 36*(2), 153-187.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103*(6), 1013-1055.

Fishman, B.J. & Krajcik, J. (2003). What does it mean to create sustainable science curriculum innovations? A commentary. *Science Education, 87*, 564-573.

Forbes, C.T. & Davis, E. A. (2007). *Beginning elementary teachers' learning through the use of science curriculum materials: A longitudinal study*. Paper presented at the annual meeting of the National Association of Research in Science Teaching, New Orleans, LA.

Forbes, C.T. & Davis, E. A. (2008). The development of preservice elementary teachers' curricular role identity for science teaching. *Science Education, 92*(5), 909-940.

Gess-Newsome, J. (2002). The use and impact of explicit instruction about the nature of science and science inquiry in an elementary science methods course. *Science & Education, 11*(1), 55-67.

Grandy, R. & Duschl, R.A. (2007). Reconsidering the character and role of inquiry in school science: Analysis of a conference. *Science & Education, 16*, 141-166.

Green, S.B. (1991). How many subjects does it take to do a regression analysis? *Multivariate Behavioral Research, 26*(3), 499-510.

Grossman, P. & Thompson, C. (2004). *Curriculum materials: Scaffolds for teacher learning?* (No. R-04-1). Seattle: Center for the Study of Teaching and Policy. Retrieved from

Haefner, L.A. & Zembal-Saul, C. (2004). Learning by doing? Prospective elementary teachers' developing understandings of scientific inquiry and science teaching and learning. *International Journal of Science Education, 26*(13), 1653-1674.

Howes, E.V. (2002). Learning to teach science for all in the elementary grades: What do preservice teachers bring? *Journal of Research in Science Teaching, 39*(9), 845-869.

Kauffman, D., Johnson, S.M., Kardos, S.M., Liu, E., & Peske, H. (2002). "Lost at sea": New teachers' experiences with curriculum and assessment. *Teachers College Record, 104*(2), 273-300.

Kelley, K. & Maxwell, S.E. (2003). Sample size for multiple regression: Obtaining regression conefficients that are accurate, not simply significant. *Psychological Methods, 8*(3), 305-321.

Kesidou, S. & Roseman, J. (2002). How well do middle school science programs measure up? Findings from Project 2061's curriculum review. *Journal of Research in Science Teaching, 39*(6), 522-549.

Knofczynski, G.T. & Mundform, D. (2008). Sample sizes when using multiple linear regression for prediction. *Educational and Psychological Measurement, 68*(3), 431-442.

Levitt, K. (2002). An analysis of elementary teachers' beliefs regarding the teaching and learning of science. *Science Education, 86*(1), 1-22.

Luft, J.A. (1999). Assessing science teachers as they implement inquiry lessons: The Extended Inquiry Observational Rubric. *Science Educator, 8*(1), 9-18.

Maxwell, S.E. (2000). Sample size and multiple regression analysis. *Psychological Methods, 5*(4), 434-458.

MDE, Michigan Department of Education (1996). *Michigan Curriculum Framework*. Lansing: Michigan Department of Education.

Milton, S. (1986). A sample size formula for multiple regressoin studies. *The Public Opinion Quarterly, 50*(1), 112-118.

NRC, National Research Council (1996). *National Science Education Standards*. Washington, D.C.: National Research Council.

NRC, National Research Council (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, D.C.: National Academy Press.

Nye, B., Hedges, L.V., & Konstantopoulos, S. (2004). How large are teacher effects? *Educational Evaluation and Policy Analysis, 2*, 237-257.

Olejnik, S. & Algina, J. (2003). Generalized eta and omega squared statistics: Measures of effect size for some common research designs. *Psychological Methods, 8*(4), 434-447.

Osborne, J.W. & Waters, E. (2002). Four assumptions of multiple regression that researchers should always test. *Practical assessment, research, and evaluation, 8*(2), Retrieved October 19, 2008 from http://PAREonline.net/getvn.asp?v=8&n=2.

Pintó, R. (2004). Introducing curriculum innovations in science: Identifying teachers' transformations and the design of related teacher education. *Science Education, 89*, 1-12.

Putnam, R.T. & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4-15.

Remillard, J.T. (1999). Curriculum materials in mathematics education reform: A framework for examining teachers' curriculum development. *Curriculum Inquiry, 29*(3), 315-342.

Remillard, J.T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research, 75*(2), 211-246.

Sawyer, R. (1982). Sample size and the accuracy of predictions made from multiple regression equations. *Journal of Educational and Behavior Statistics, 7*, 91-104.

Schneider, R.M., Krajcik, J., & Blumenfeld, P. (2005). Enacting reform-based science materials: The range of teacher enactments in reform classrooms. *Journal of Research in Science Teaching, 42*(3), 283-312.

Schwartz, D., Lin, X., Brophy, S., & Bransford, J.D. (1999). Toward the development of flexibly adaptive instructional design. In C. Reigeluth (Eds). *Instructional-design Theories and Models: A New Paradigm of Instructional Theory*. (pp. 183-214). Mahway, N.J.: Erlbaum.

Schwarz, C., Gunckel, K., Smith, E., Covitt, B., Enfield, M., Bae, M., & Tsurusaki, B. (2008). Helping elementary pre-service teachers learn to use science curriculum materials for effective science teaching. *Science Education, 92*(2), 345-377.

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

Sim, C. (2006). Preparing for professional experiences - incorporating pre-service teachers as 'communities of practice'. *Teaching and Teacher Education, 22*, 77-83.

Smithey, J. & Davis, E. A. (2002). Preservice elementary science teachers' distributed expertise in an online community of practice. In R. Stevens & T. Satwicz P. Bell (Eds). *Proceedings of the Fifth International Conference of the Learning Sciences (ICLS)*. (pp. Seattle, WA: Lawrence Erlbaum.

Southerland, S.A. & Gess-Newsome, J. (1999). Preservice teachers' views of inclusive science teaching as shaped by images of teaching, learning, and knowledge. *Science Education, 83*, 131-150.

Squire, K.D., MaKinster, J.G., Barnett, M., Luehmann, A.L., & Barab, S.L. (2003). Designed curriculum and local culture: Acknowledging the primacy of classroom culture. *Science Education, 87*(468-489).

Thompson, B. (2007). Effect sizes, confidence intervals, and confidence intervals for effect sizes. *Psychology in the Schools, 44*(5), 423-432.

Trusty, J., Thompson, B., & Petrocelli, J.V. (2004). Practical guide for reporting effect size in quantitative research in the *Journal of Counseling & Development*. *Journal of Counseling and Development, 82*, 107-110.

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87*(1), 112-143.

Windschitl, M. (2004). Folk theories of 'inquiry': How preservice teachers reproduce the discourse and practices of an atheoretical scientific method. *Journal of Research in Science Teaching, 41*(5), 481-512.

Zembal-Saul, C., Blumenfeld, P., & Krajcik, J. (2000). Influence of guided cycles of planning, teaching and reflection on prospective elementary teachers' science content representations. *Journal of Research in Science Teaching, 37*(4), 318-339.

Zembal, C., Starr, M., & Krajcik, J. (1999). Constructing a framework for elementary science teaching using pedagogical content knowledge. In J. Gess-Newsome & N. Lederman (Eds). *Examining* *pedagogical content knowledge: The construct and its implications for science education*. (pp. 237-256). The Netherlands: Kluwer Academic Publishers.

Zientek, L.R., Capraro, M.M., & Capraro, R.M. (2008). Reporting practices in quantitative teacher education research: One look at the evidence cited in the AERA panel report. *Educational Researchers*, *37*(4), 208-216.

Appendix

Inquiry Scoring Rubric for Lesson Plans

	3	2	1	0
Lesson engages students in scientifically oriented questions	Lesson uses investigation question that is feasible, worthwhile, contextualized, meaningful, ethical, and sustainable. Inv. questions and other questions are in 'how' rather than 'why' form. Inv. Question is answerable in light of the lesson activities and other questions explicitly scaffold students' investigation and sense-making.	Lesson uses investigation question that meets at least some of the criteria for effective inv. questions. Inv. Question may be in 'why' or 'how' form. Question is at least to some extent answerable in light of the lesson activities. Lesson provides at least some additional questions teachers may use to reasonably support students' investigation and sense-making.	Minimal evidence of use of scientific question and questioning. Investigation question may be present but meet few to no criteria for effective investigation questions. Questions may be in 'why' rather than 'how' form. Lesson makes unproductive suggestions for additional questions teachers can use to support students Questions are likely not answerable in the classroom contexts.	No evidence
Lesson engages students in gathering, organizing, and analyzing and data	Students collect, organize, and analyze data/evidence. Opportunities to gather, organize, and analyze evidence are linked to the investigation question and/or phenomenon under investigation.	Students do 2 out of 3 of the following: collect, organize, and analyze data/evidence. Opportunities to gather, organize, and analyze evidence are at least somewhat linked to the investigation question and/or phenomenon under investigation.	Students do 1 out of 3 of the following: collect, organize, and analyze data/evidence. Opportunities to gather, organize, and analyze evidence are marginally linked to the investigation question and/or phenomenon under investigation.	No evidence
Lesson engages students in formulating explanations from evidence to address scientifically oriented questions.	Opportunities to construct explanations are connected to the evidence and data collected. Claims can be supported by evidence collected. Opportunities to construct explanations are connected to the investigation question and/or phenomenon under investigation.	Opportunities to construct explanations are less explicitly connected to the evidence and data collected and the investigation question and/or phenomenon under investigation or lesser degrees of both. Claims may be supported by evidence collected.	Opportunities to construct explanations are either marginally connected to the evidence and data collected and the investigation question and/or phenomenon under investigation or, in one case or the other, not at all linked. Claims are likely not to be able to be supported with evidence collected.	No evidence
Lesson engages students in evaluating	Lesson supports students to engage in dialogues, compare results, or check	Lesson supports students to evaluate their explanations by comparing to at	Lesson supports students to evaluate explanations without taking	No evidence

their explanations in light of alternative explanations	their results with those proposed by the teacher or instructional materials. Lesson supports students to do so in ways that are highly likely to lead students to explanations that are consistent with currently accepted scientific knowledge and the lesson's standards-based learning goals.	least one alternative explanation. Lesson supports students to do so in ways that are reasonably likely to lead students to explanations that are consistent with currently accepted scientific knowledge and the lesson's standards-based learning goals.	alternative explanations into account. Lesson is unlikely to lead students to explanations that are consistent with currently accepted scientific knowledge and the lesson's standards-based learning goals.	
Lesson engages students in communicating and justifying their explanations.	Lesson provides students with opportunities to share and justify their question, procedures, evidence, proposed explanation, and review of alternative explanations.	Lesson provides students with opportunities to share AND justify some aspect of their question, procedures, evidence, proposed explanation, and review of alternative explanations.	Lesson provides students with opportunities to share OR justify some aspects of their question, procedures, evidence, proposed explanation, and review of alternative explanations.	No evidence