SUPPORTING PRESERVICE ELEMENTARY TEACHERS' CRITIQUE AND ADAPTATION OF SCIENCE CURRICULUM MATERIALS USING TWO TYPES OF EDUCATIVE SUPPORTS

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A paper presented at the July 2007 Knowledge Sharing Institute, Washington DC.

This research is funded by a PECASE/CAREER Award to the second author from the National Science Foundation, REC grant #0092610. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors. The authors thank the CASES research team for their feedback and the preservice elementary teachers for their interest and participation in this study.

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Abstract: Critiquing and adapting curriculum materials are essential components of teachers' work. However, preservice teachers encounter many challenges in engaging in these tasks and thus need support. This study explores the use of educative curriculum materials in helping preservice teachers develop beginning levels of proficiency in critiquing and adapting curriculum materials. These materials contain educative supports specifically intended to support teacher learning, in addition to student learning. However, little is known about how educative supports should be written in order to support teacher learning. This study examines the affordances and constraints of two different forms of support, general educative supports written as expository text and lesson-specific educative supports written as narratives, in helping preservice elementary teachers critique and adapt science curriculum materials. Results show that the narratives helped the preservice teachers identify specific instructional strategies to use with their students and view the educative supports as useful and relevant and thus motivated them to use the supports in their analysis. In contrast, the expository supports helped preservice teachers identify important principles of practice to use in their analysis of lesson plans and see that the ideas in the educative support extended to other lessons. Implications for science teacher education and the design of educative curriculum materials are discussed.

Curriculum materials play a fundamental role in shaping classroom practice. Curriculum materials are written resources designed for teachers to use with students during instruction. These materials contain content and skills for students to learn, illustrate connections among ideas, provide activities for learning about those ideas, suggest sequences for these activities, and specify pedagogical methods (Remillard, 2000). Curriculum materials are intimately connected to teachers' daily work (Ball & Cohen, 1996; Collopy, 2003). Teachers use these curricular tools to help them make thoughtful decisions about classroom practice (Brown & Edelson, 2003; Lloyd, 1999; Shulman, 1986). Even more, teachers teaching outside their content area and teachers entering the field of teaching tend to rely extensively on such materials to plan and enact instruction (Ball & Feiman-Nemser, 1988; Grossman & Thompson, 2004; Kauffman et al., 2002; Nicol & Crespo, 2006; Powell, 1997). "Of all the different instruments for conveying educational policies, [curriculum materials] exert perhaps the most direct influence on the tasks that teachers actually do with their students each day in the classroom" (Brown & Edelson, 2003, p. 1).

A growing body of research has focused on how teachers use science and mathematics curriculum materials to design and enact instruction (Ben-Peretz, 1990; Collopy, 2003, Davis, 2006; Enyedy & Goldberg, 2004; Fishman, Marx, Best, & Tal, 2003; Lloyd, 1999; Pintó, 2004; Remillard, 1999; Remillard & Bryans, 2004; Schneider, Krajcik, & Blumenfeld, 2005; Schwarz et al., in review). Curriculum use, here, refers to "how individual teachers interact with, draw on, refer to, and are influenced by material resources designed to guide instruction" (Remillard, 2005, p. 212). In investigating teachers' use of curriculum materials, this body of research has shown that effective teachers use curricular resources as a guide and that critiquing and adapting curriculum materials are essential aspects of teachers' work. Critiquing materials entails evaluating a set of materials by identifying its strengths and weaknesses (Davis, 2006; Schwarz et al., in review; Sherin & Drake, in review), and adapting materials entails modifying or making

changes to a lesson during planning and enactment (Davis, 2006; Drake & Sherin, 2006). I use the term 'analysis' to refer simultaneously to both practices.

Teachers critique and adapt curriculum materials in response to a number of factors. For example, school districts routinely adopt and mandate the use of published curricular programs. Even though these materials may equip teachers with much needed resources, such materials vary in quality. For example, recent reviews of science curriculum materials show that many existing curricular programs are of poor quality, failing to focus on key scientific ideas and support students in learning about those ideas (Hubisz, 2003; Kesidou & Roseman, 2002; Ochsendorf, Lynch, Pyke, O'Donnell, & Faubert, 2004; Stern & Roseman, 2004). Some curriculum materials also fail to embrace an inquiry-oriented approach to science teaching and thus are inconsistent with reform-based standards and benchmarks (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). Thus, teachers need to critique and adapt curriculum materials in order to compensate for their weaknesses and ultimately support students in meeting crucial content and inquiry standards.

Additionally, curriculum materials are designed for a wide audience and general context and thus may not help teachers target specific learning goals (Brown & Edelson, 2003) or meet the needs of an increasingly diverse population of students (Rosebery, 2005). It is important for teachers to use curriculum materials in flexibly adaptive ways in order to meet their specific contextual needs and anchor students' learning in productive ways (Ball & Cohen, 1996; Barab & Luehmann, 2003; Brown & Edelson, 2003; Enyedy & Goldberg, 2004; Pintó, 2004; Squire et al., 2003). Thus, in creating learning experiences for students, teachers need to make local adaptations to curriculum materials (even high quality materials) in order to take into account their own understandings and goals, their students' needs and strengths, and classroom contexts.

Even though critiquing and adapting curriculum materials are essential aspects of teaching practice, aspiring and beginning teachers encounter difficulties in engaging in these tasks (Ball & Feiman-Nemser, 1988; Bullough, 1992; Davis, 2006; Grossman & Thompson, 2004; Lloyd & Behm, 2005; Mulholland & Wallace, 2005, Nicol & Crespo, 2006; Schwarz et al., in review; Valencia et al., 2006). Teachers who do not know how to analyze curriculum materials in productive ways may fail to recognize the strengths and weaknesses in the materials. Consequently, they may make counterproductive changes or may not make much needed modifications to lessons. Therefore, new teachers need support in developing beginning levels of proficiency in critiquing and adapting curriculum materials—a relatively unexplored area in the literature (Lloyd & Behm, 2005; Nicol & Crespo, 2006). More specifically, few studies have investigated preservice *elementary* teachers' critique and adaptation of *science* curriculum materials (Davis, 2006; Davis, Petish, & Smithey, 2006; Schwarz et al., in review). Therefore, in this study we examine how preservice elementary teachers engage in these authentic teaching tasks as they are provided with two different forms of support in their science methods course that aim to develop their knowledge and skills for analyzing curriculum materials.

Theoretical Framework

This study is grounded in the theoretical perspective that teachers and curriculum materials participate together in a dynamic, collaborative relationship (Brown & Edelson, 2003; Lloyd, 1999; Remillard, 1999; 2000; 2005; Schneider & Krajcik, 2002; Sherin & Drake, in review). In this participatory relationship, both the teacher and curriculum are active participants in the design of the planned curriculum and co-construction (with students) of the enacted

curriculum (Remillard, 2005). Both teacher and curriculum materials make unique and valuable contributions to the relationship, resulting in better teaching and learning (Russell, 1997). Thus, the best learning environment is fostered by a partnership between teacher and curriculum.

Drawing on socio-cultural perspectives (e.g., Cole & Engestrom, 1993; Vygotsky, 1978; Cole, 1996; Wertsch, 1991), curriculum materials shape the participatory relationship as products of social activity constructed by cultural and historical meanings. These subjective meanings shape curriculum materials by determining what science is important to teach and what it means to teach science. These conceptions mediate teachers' interactions with the curriculum materials, shaping how teachers read and interpret the materials and ultimately what they learn and how they use them in practice. Teachers also serve as active participants in this partnership. In reading and interpreting written materials, teachers draw upon their experiences, beliefs, knowledge, and instructional goals. These personal resources help teachers bring meaning to the materials and ultimately shape how the materials are enacted in practice (Brown & Edelson, 2003; Remillard, 1999; 2005; Sherin & Drake, in review). Thus, not only are teachers shaped and changed through their interactions with the materials but also the curriculum materials are simultaneously shaped and changed as teachers use and adapt them in ways that address their own unique characteristics, needs, and goals.

Challenges to Helping Preservice and Beginning Teachers Analyze Curriculum Materials

One pivotal assumption grounded in the theoretical perspective described above is the idea that teachers need to have an analytical relationship with curriculum materials in order to use curriculum materials in a way that is productive for both student and teacher learning (Davis, 2006; Gunckel et al, in review; Schwarz et al., in review). This relationship involves being able to identify the strengths and weaknesses in curriculum materials. It also involves modifying the materials in productive ways that draw on students' experiences and resources and address students' needs and crucial learning goals. Productive modifications are changes guided by principles that are relevant to teachers' own instructional goals and consistent with reform goals and standards. In order to make productive curricular decisions, teachers need help in developing the professional knowledge and skills needed to engage in an analytical relationship with curriculum materials.

Support is especially crucial for aspiring and beginning teachers, who face a unique set of challenges in learning how to use curriculum materials in productive ways. For example, some preservice and new teachers follow curriculum materials as written because they do not have adequate knowledge for analyzing materials (Ball & Feiman-Nemser, 1988; Grossman & Thompson, 2004; Mulholland & Wallace, 2005, Nicol & Crespo, 2006; Valencia et al., 2006). For those new teachers who do critique and adapt curriculum materials, many are able to identify a variety of principles to guide their analysis of lesson plans (Davis, 2006; Gunckel et al., in review; Schwarz et al., in review). However, their ideas are sometimes limited in scope to the practical and affective aspects of teaching, such as the explicitness and feasibility of the procedures, the helpfulness of the teacher background information, the ease of obtaining materials, and the extent to which activities are fun and engaging for students (Bullough, 1992; Gunckel et al., in review; Lloyd & Behm, 2005; Mulholland & Wallace, 2005; Nicol & Crespo, 2006; Schwarz et al., in review; Southerland & Gess-Newsome, 1999). Additionally, some preservice and beginning teachers are able to identify and apply criteria in their analysis but need opportunities to learn how to address the weaknesses they find in the materials. Without support, some may choose not to adapt the materials (Lloyd & Behm, 2005; Valencia et al., 2006) or may

only make superficial changes that do not address significant weaknesses (Grossman & Thompson, 2004; Nicol & Crespo, 2006). Still others may modify materials in ways that distort the point of the materials (Ball & Feiman-Nemser, 1988).

Supporting Preservice Teachers' Analysis of Lesson Plans Using Educative Supports

For all these reasons, preservice and beginning teachers need scaffolded experiences with curriculum materials that build upon their strengths in order to help them develop their professional knowledge and skills for analyzing curriculum materials (Ball & Feiman-Nemser, 1988; Davis, 2006; Grossman & Thompson, 2004; Gunckel et al., in review; Lloyd & Behm, 2005; Lynch, 1997; Powell, 1997; Schwarz et al., in review; Valencia et al., 2004). This includes helping new teachers identify and apply new ideas about principles representing complex ideas about teaching in their analysis of lesson plans. By learning how to become effective curriculum decision makers, aspiring and beginning teachers will be able to overcome the inevitable limitations of curriculum materials as well as take advantage of the learning opportunities within them. Additionally, they will be able to modify materials in ways that allow them to attend to their own needs, strengths, and context and support their own students in achieving crucial learning goals.

However, little is known about how science teacher educators can support preservice and new teachers in developing beginning levels of proficiency in these teaching practices (Davis, 2006). This study explores the use of educative curriculum materials in providing this support. Educative curriculum materials contain curricular features specifically intended to support teacher learning, in addition to student learning (Ball & Cohen, 1996; Collopy, 2003; Davis & Krajcik, 2005; Heaton, 2000; Schneider, 2006). These curricular features serve as educative supports by developing teachers' knowledge about content, pedagogy, and learners (Collopy, 2003; Schneider & Krajcik, 2002). To promote teacher learning, these materials are "designed to speak to teachers, not merely through them" by providing teachers with rationales for ideas and suggestions given in the materials (Remillard, 2000, p. 347; see also Ball & Cohen, 1996; Davis & Krajcik, 2005). These rationales engage teachers in the ideas underlying curriculum developers' pedagogical judgments. Educative supports embedded in curriculum materials also provide teachers with guidance on how to use and adapt curricular suggestions and strategies to achieve productive instructional ends (Remillard, 2000; Davis & Krajcik, 2005; Schneider & Krajcik, 2002). In these ways, curriculum materials that are designed with explicit pedagogical support have the potential to help teachers make productive and informed decisions about how to design instruction for their students.

However, little is known about how educative supports should be written in order to help teachers develop their ideas for how to use a specific lesson and to be able to apply those ideas to other lessons. Drawing upon Shulman's (1986) categorization of teacher knowledge, this study examines the affordances and constraints in using general educative supports versus lesson-specific educative supports with the end of goal of promoting teacher learning. General educative supports are intended to support teachers' propositional knowledge by describing general principles of practice that relate to many lessons; in this study these supports are written as expository text. In contrast, lesson-specific educative supports aim to support teachers' case knowledge by providing exemplars of principles, implicitly targeting a general principle by describing a lesson-specific instance of the principle in practice. These supports are written as narratives in this study. By investigating these two different forms of support, this study aims to uncover whether these two different forms of support will help preservice teachers identify

important principles of practice, apply those principles in their analysis of specific lesson plans, neither, or both.

Purpose of the Present Study

To assess the affordances and constraints of these two particular forms of educative support, we describe how preservice elementary teachers used and learned from educative supports in their critique and adaptation of inquiry-oriented science curriculum materials when they received one of two types of educative support: expository text or situated narratives. The research questions guiding our study include:

1. How do preservice teachers use the different forms of educative supports?
2. What are preservice teachers' views on the usefulness of the different forms of educative supports?
3. How do the different forms of educative supports help preservice teachers
    a. Develop their understanding of the principles targeted in the educative supports?
    b. Apply the general principles targeted in the educative supports in their analysis of lesson plans?
    c. Apply specific instructional approaches described in the narrative educative supports in their analysis of lesson plans?

By uncovering the affordances and constraints of different forms of educative support in supporting preservice elementary teachers' analysis of lesson plans, this study contributes to the field's understanding of how teacher educators can support preservice teachers in learning how to critique and adapt curricular resources. Additionally, this study has implications for the design of educative curriculum materials, providing insights into how educative supports for curriculum materials can be designed to promote teacher learning.

Methods

Research Participants & Context

This research study was focused on one elementary science methods course at a large Midwestern university in the United States. This course took place during the third semester of the undergraduate teacher preparation program. The participants in this study were drawn from two sections of the science methods course. All 28 preservice teachers in one section of the course gave their consent for their coursework to be analyzed for the study. Twenty-seven of the 28 students in the other section also consented, but we collected data from only 25 individuals in this section of the course because data were missing from two preservice teachers. We informed participants that they could withdraw their consent at any time during the study, though none did so, and that confidentiality would be maintained through use of pseudonyms for all participants. The preservice elementary teachers were representative of the population of elementary teachers in the United States. In other words, the majority of the preservice teachers were white and female (NCES, 2005). Most were also traditional fourth-year college students in their final year of study.

Preservice teachers typically entered the teacher education program during their junior year and experienced the program as a cohort. The program consisted of four-semesters of intensive professional study and was aligned with recommendations outlined by teacher education reform calls (e.g., INTASC, 1992; NCATE, 1987) and standards documents (e.g., AAAS, 1993; NCTM, 1991; NCSS, 1994; NRC, 1996). This program entailed strong academic

preparation and intensive study and teaching in an elementary classroom. The first semester of the program had an overarching emphasis on learners and learning and involved an educational psychology course, an introductory elementary teaching course, and a literacy methods course. The second semester emphasized knowledge, knowing, and instruction and involved a foundations of education course focused on multiculturalism, another literacy methods course, and a social studies methods course. The third semester focused on instruction with an emphasis on integrating ideas about knowledge, knowing, learners, and learning. During this semester, preservice teachers completed a mathematics methods course and a science methods course—the latter course being the focus of this study. In addition to relevant university coursework, preservice teachers also spent six hours each week of each semester in a K-6 classroom under the mentorship of an experienced classroom teacher. The final semester of the program entailed full-time student teaching.

The elementary science methods course itself met for three hours each week during the fall semester of their senior year. The second author taught the science methods course. The course was organized around three overarching conceptual themes. The first theme focused on helping the preservice teachers develop their understanding of inquiry-oriented science teaching. The second theme of the course focused on helping preservice teachers identify, interpret, and work with students' ideas about science. The third theme focused on engaging preservice teachers in critiquing and adapting curriculum materials. The second and third themes were the focus of this investigation.

Lesson Plan Analysis Assignments and Educative Supports

Preservice teachers completed three lesson plan analysis assignments distributed evenly across the semester. The purpose of the assignments was to help the preservice teachers develop their knowledge and skills for critiquing and adapting science curriculum materials. They completed the assignments individually as homework and had one week to complete each assignment. Preservice teachers received different lesson plans for each assignment, drawn from the CASES Weather unit. CASES is an online learning environment that provides new elementary teachers with educative curriculum materials intended to help them develop an understanding of inquiry-oriented science teaching (http://cases.soe.umich.edu; see Davis, Smithey, & Petish, 2004).

An educative support accompanied each assignment, and the educative support for each assignment targeted a specific principle of practice related to helping preservice teachers identify, interpret, and work with students' ideas—an important goal of the science methods course. It is important to support preservice teachers in learning about these important teaching tasks because preservice teachers are often unaware of the power of students' ideas to shape what they learn and have limited strategies for bringing about significant changes in students' conceptions (Smith, 1999; Smith & Neale, 1989). For the first assignment the support focused on making student thinking visible (principle 1), for the second assignment on probing student thinking (principle 2), and for the third assignment on constructing connections between in-class experiences and students' ideas about science (principle 3). In addition to helping preservice teachers identify important principles that they could use to analyze lesson plans, these principles also served as "tracers" to help us determine if and when preservice teachers used the educative supports in their analyses.

Even though each section of the methods course received educative supports targeting the same principles, each section received a different form of support. One section received

educative supports written as expository text while the other section received educative supports written as narratives. The expository supports explicitly stated the general principle of practice and explained what it meant and why it was important. The narrative supports implicitly targeted the general principle of practice by describing an exemplar of the principle. They described how a fictional teacher (Kendra) addressed a weakness in the lesson plan related to the principle and why she thought it was important to attend to the principle. Even though the form of support differed between sections of the course, the rationales provided in the expository supports were the same as the ones provided in the narratives for each assignment. Table 1 shows an example of the narrative and expository supports that the preservice teachers received in their first lesson plan analysis assignment. Appendix A includes the other educative supports that the preservice teachers received in the second and third assignments.

Table 1
Educative Supports from the First Lesson Plan Analysis Assignment

Expository Educative Support
General Principle: Teachers need to identify, interpret, work with, and support students' ideas to help students make sense of the science. Specific Principle: Teachers need to make students' thinking visible (MTV). Students do not come to instruction as blank slates. Instead, students come with a range of ideas that they use to interpret and understand new concepts. Therefore, students' existing ideas influence how they learn new ideas. Students sometimes come to instruction with alternative ideas about science topics. Alternative ideas are scientifically inaccurate ideas that may have developed from previous experiences that students have had with the phenomenon. Therefore, it is important to make students' thinking visible. This means to find ways to make students' ideas explicit by providing opportunities for students to communicate their ideas to teachers and/or peers. Why is this important? Making thinking visible (MTV) has benefits for both students and teachers. Making thinking visible enables students to become aware of their own ideas. This helps them to be better positioned to later examine and refine their ideas. If students share those ideas publicly, then students can also learn about others' ideas and communicate their ideas to teachers and peers. Making thinking visible thus also enables the teacher to better understand what students know, what they don't know, and where they are having difficulties. This lets the teacher plan instruction to help students examine their own ideas and then build on and modify those ideas as they learn about science.
Narrative Educative Support
Kendra had her students work in small groups to answer the questions, "What is wind?" and "What causes the wind?" She thought these were good questions to begin the lesson with because she remembered learning in a professional development workshop about the importance of "MTV"—making thinking visible. She then realized that the lesson plan suggested that she jump right into the activity without having her students make their thinking visible to the whole class. So Kendra decided to deviate from the lesson plan so her students could share their ideas as one large group. She felt that making students' thinking visible was important so she could see what her students knew and did not know about the wind. Making thinking visible also enabled each student to see how he or she and the other students were thinking about these questions. As

students shared their ideas, she recorded them on chart paper without correcting any of her students' ideas. Kendra learned from this discussion that many of her students thought that there was no difference between air and wind and that the trees caused the wind. The whole class discussion caused the lesson to take more time than she had initially anticipated, but Kendra felt that it was worthwhile. It gave her a chance to see that her students had some alternative ideas about wind and to think about how to address them. She was glad she remembered MTV!

With regard to the format of the assignment, each lesson plan analysis assignment asked preservice teachers to read through the lesson plan first and then the educative support. It then asked them to identify strengths and weaknesses in the lesson plan, in light of the lesson plan, the principles, and their work in class. The assignment also asked them to describe how they would change the lesson to address the weaknesses. The assignment concluded with asking them to discuss where they thought their ideas about strengths, weaknesses, and changes came from.

Data Sources

Both sections received identical pre/posttests. These were completed at the beginning and end of the semester. The purpose of the pre/posttest was to describe how preservice elementary teachers critiqued and adapted science lesson plans without support, and how their analyses changed after reading and using the educative supports in the lesson plan analysis assignments. The preservice teachers completed these tasks individually as homework and had one week to work on the assignment. The pre/posttests were similar in form to the lesson plan analysis assignments except without any educative supports. The pre/posttest asked preservice teachers to identify the strengths and weaknesses in the lesson plan, make modifications to address the weaknesses, and discuss the origin of their analysis ideas. The lesson plan that the preservice teachers analyzed was the same for both the pretest and posttest.

As previously described, preservice teachers also completed three lesson plan analysis assignments during the semester. The purpose of these assignments was to describe how the preservice teachers used and what they learned from two different forms of educative supports that were intended to help them identify important principles of practice and apply them to their analysis. These assignments also shed light on how the two different forms of support shaped preservice teachers' analysis of science lesson plans.

Finally, a subset of preservice teachers (n=7) was interviewed—three from the narrative group and four from the expository group. These interviews took place at the beginning, middle, and end of the course. All three interviews were audio-taped and transcribed, each lasting approximately one hour. The first and third interviews asked preservice teachers to describe their understanding of what it means to identify and work with students' ideas about science and explain why they think these practices are important to science teaching. The preservice teachers then discussed how they would engage in these practices as they teach a unit on plants. The interviews also had the preservice teachers describe the main ideas they focused on in their pre/posttest, analyze the lesson plan from the pre/posttest with regard to identifying and working with students' ideas, and describe the origin of their analysis ideas. The second interview asked preservice teachers to describe how they completed the lesson plan analysis assignments and used the educative supports in their analysis. This interview also focused on preservice teachers' perceptions on the usefulness of the educative supports. Preservice teachers also completed a 'think aloud,' sharing any thoughts they had as they read through a lesson plan and educative support that they had received in their lesson plan analysis assignment. Similar to the first and

third interviews, the second interview also asked preservice teachers to analyze a lesson plan from one of their assignments with regard to identifying and working with students' ideas and describe the origin of their analysis ideas. Appendix B includes the questions used in the interview protocols.

Data Analysis

Data analysis involved iterative analysis and revision of the coding scheme (Miles & Huberman, 1994). We derived the initial coding key from the ideas embedded in the educative supports and included codes related to preservice teachers' use of the educative supports, views on the usefulness of the supports, understanding of the principles, use of the instructional strategies described in the narratives, descriptions of the origin of their analysis ideas, and relevant tracers from the educative supports. During analysis, we revised the coding key to account for emergent sub-codes and all of the data was recoded using a final coding scheme. Appendix C lists the codes used in the analysis along with sub-codes and their descriptions. We then quantified some of the codes in order to foster more meaningful comparisons of the data by allowing patterns to be identified and further explored between treatment conditions and across time (Chi, 1997). More specifically, we calculated percentages within lesson plan analysis assignment and pre/posttests in order to determine how many preservice teachers attended to the principle and used tracers in their analyses, attended to specific instructional approaches described in the narratives, and attributed their analysis ideas to the educative supports.

We then identified emergent themes in the coded and quantified data in order to describe similarities and differences between the two treatment conditions with regard to their use of the educative supports, their perceptions of the usefulness of the supports, their understanding of the general principles, and their ability to analyze lesson plans with regard to the principle. We also uncovered patterns across time in order to discern any changes in preservice teachers' knowledge and skills for analyzing lesson plans with regard to the principles. After identifying themes and patterns in the data, we generated preliminary assertions for each research question based on the data and tested their viability by seeking both confirming and disconfirming evidence from multiple data sources (Erickson, 1986). To enhance the validity of the study, we triangulated data between the interviews, pre/posttest, and lesson plan analysis assignments to support the most robust assertions (Johnson, 1997; Krefting, 1991). We also discussed emerging findings at regular meetings with impartial colleagues. This peer review process provided further feedback on the coding schemes, emergent patterns, and interpretations, thereby contributing to the credibility of the assertions in this study (Lincoln & Guba, 1985).

Results

Use of the Educative Supports

Most of the preservice teachers in the narrative group as well as some of the preservice teachers in the expository group used the educative support in their lesson plan analysis assignments. For example, all of the interviewees from the narrative group and two of the four interviewees from the expository group said that they completed the assignments by first reading through the lesson plan and taking notes about its strengths and weaknesses and then reading through the educative support and using it to think through the lesson plan again. The following excerpts illustrate how Tracy and Summer, preservice teachers from each treatment condition, described their use of the educative supports in completing the assignments:

> I think I read the lesson plan first and then the pink sheet and then I like went back and looked at the lesson plan again to see if the pink sheet helped me think about the lesson plan more. (Tracy, Narrative Group, Interview 2)

> I read it through first, and as I read, I make notations if something stands out to me. Then I read this second sheet, because Betsy always gives us one of these for each of them too which is like a principle to kind of focus on as we're doing this. So then I read this and then I think about the lesson again in terms of this principle. (Summer, Expository Group, Interview 2)

However, some preservice teachers in the expository group did not use the educative supports in completing the lesson plan analysis assignments. For example, two interviewees said they completed the assignments by reading only though the lesson plan and taking notes on it. For example, Sally, a preservice teacher from the expository group, described how she completed the assignment without the use of the educative support:

> First I read one time and then I read through a second time and then I make comments in the margin about my initial reactions to some of the things and then I go to the questions like describe the strengths, weaknesses and changes and stuff. And I look at my comments in the margins and basically match it up to the category…that's usually what I do. Read it once, go through it again, comments in the margin and then answer the questions. (Sally, Expository Group, Interview 2)

When asked why she did not use the educative support, Sally explained:

> Honestly, I didn't even read the principle…. If I don't have to do it, if it's not a part of the questions that I have to answer, like a question connecting the lesson plan and the principle, then I'm really not going to spend time thinking about it. (Sally, Expository Group, Interview 2)

Other evidence suggesting that most of the preservice teachers in the narrative group but only some of the preservice teachers in the expository group used the educative supports includes the differences in the percentage of preservice teachers using the tracers from the educative supports. The educative supports from the first, second, and third lesson plan analysis assignments included the tracers making students' thinking visible, probing student thinking, and constructing connections between in-class activities and students' ideas, respectively. Other tracers specific to the narratives included Kendra (the name of the fictional teacher), story, and pink sheet. Other tracers specific to the expository supports included principles and yellow sheet. Seventy-seven percent of the preservice teachers in the narrative group, on average, used the tracers in each assignment, whereas an average of only 43% of the preservice teachers used the tracers in the expository group (see Table 2). This finding shows that most of the preservice teachers in the narrative group actually read and used the educative supports. In contrast, fewer preservice teachers in the expository group appeared to have used the educative supports in their analyses.

Table 2
Percentage of Preservice Teachers Who Used Tracers in their Lesson Plan Analysis Assignments

	Assignment 1	Assignment 2	Assignment 3
Narrative Group	84%	72%	76%
Expository Group	43%	29%	57%

Additionally, when the educative supports were used, the preservice teachers from the two treatment conditions engaged in different thought processes when they read through their respective educative support. In the narrative group, the preservice teachers tended to think in similar ways as they read through the educative support. They typically agreed with the instructional strategy that the fictional teacher used in her adaptation of the lesson and then explained why they liked her modifications. The following two excerpts illustrate this type of thinking as the preservice teachers read through an educative support focused on helping students construct connections between in-class activities and their ideas:

> So I just, I agree with her. I think that it would help….I like that idea [of revisiting the question at the beginning of the lesson] just because it gives them a chance to reflect and go back, because it gives them a chance to reflect and think about, "Okay, so this is what I thought at the beginning of this. And how have my ideas changed and what am I still confused about?" (Eva, Narrative Group, Interview 2)

> I think that's also good to go back and change, so now students will be like oh, I get this and this and this, and so to give them a chance to go back and, I guess it's also a good assessment tool to see if their ideas have changed and how they've developed from this experiment. (Tracy, Narrative Group, Interview 2)

In contrast, the preservice teachers in the expository group tended to think in a variety of ways about their educative support. The preservice teachers' ideas centered on the principle targeted in the educative support. With regard to the principle, they provided rationales for its importance, related it to their personal experiences as learners and teachers, and related it to the lesson plan itself. Kayla and Sally illustrate these ideas with regard to the constructing connections principle from the educative support in the third lesson plan analysis assignment:

> I just think that this is a really important lens because I think if we aren't helping kids to make these connections they kind of (a) don't understand why they're doing certain things and (b) it's not meaningful to them. I mean that's a big reason why I didn't like science when I was little because I didn't really know why we were doing something and, especially when you're using models like this, I think it is hard for students to understand how this eraser and a pan of water with salt is similar to what's happening in the sky, so I just think it's a really important part of teaching science when using a model. (Kayla, Expository Group, Interview 2)

> I think situating what they do in class outside of the classroom helps them, because a lot of times you find out whatever they learn from a classroom they keep in the classroom and they don't relate it to real life phenomena so helping them to do that is really important…In my content conversation, I asked the students, "Can sound travel through solids and liquid?"

> And because they've only been working with gas in the classroom—they did some solids but mostly it was sound waves in the air and stuff like that—she couldn't do it, and so then I gave her the examples about swimming and about riding in a car, for solids and liquids and stuff. Those are real phenomena and things that she'd do but she didn't make the connection. And so when she said, "No, it can't travel through a solid because it's hard," I mean, that shows she knows that solids are hard but she had problems situating it outside of the classroom. (Sally, Expository Group, Interview 2)

Additionally, in relating the principle to the lesson, some preservice teachers from the expository group also made suggestions for how to adapt the lesson plan in order to address weaknesses in the lesson with regard to the principle as well as provided rationales for their adaptations. For example, Lily described how she would add a whole class discussion at the end of the lesson to help students construct connections between the cloud model and the real phenomenon.

> I think it's probably a good idea to just bring all of it out in the open and make it obvious and make it explicit what they've done, what they thought, what they do, and then what they learned at the end. Like having a discussion, because they might not see these on their own but with support they can do so. I feel like it's hard to connect this model and the real world. But if you have a discussion about it and you make that explicit to them, it's more likely that they'll be able to keep that connection in their head, and not just think about the experiment with the eraser and salt. (Lily, Expository Group, Interview 2)

In sum, these findings show that most of the preservice teachers from the narrative group used the educative supports but only some of the preservice teachers from the expository group did so. Additionally, when both groups read through their respective educative support, they engaged in different types of thinking. The narrative group focused on the lesson-specific features of the educative support rather than on the general principle underlying the ideas in the support. In contrast, the expository recognized the general principle targeted in the educative support and used it to critique and adapt the lesson plan.

Perceptions of the Usefulness of the Educative Supports

The preservice teachers' perceptions of the usefulness of the educative supports differed greatly between the two treatment conditions. The narrative group viewed their educative supports as useful for many reasons. First, they saw the narratives as helping them visualize what the lesson would look like in practice. The following excerpt illustrates this perspective:

> There's so many blanks in a lesson plan like this, like there are things missing that would need to change for your class or for, you know, how students learn, that I think things sometimes just help, like the stories help fill it in. It helps me see just how it would be carried out, because this [lesson plan] is all very theoretical I guess, and this [the narrative] is kind of more of like how it would go in a classroom…more like what maybe are like the real things that might happen. (Tracy, Narrative Group, Interview 2)

The preservice teachers in the narrative group also viewed the educative support as useful for identifying a problem within the lesson and providing a clear example of how to modify the lesson and the reasoning behind the change. For example, Eva explained how she used the

educative support to help her address a specific problem with the lesson, saying, "I liked it the first time we got it because it gave me a clear example and then her [Kendra's] reasoning behind it of why you change something and how you would change it" (Interview 2). Tracy also had a similar perspective:

> This story sheet …it's not like, oh, you have x, y, and z prepared before lesson. It's more like, okay, there's going to be this problem that students have with understanding cloud formation, so this is how you can help them. (Tracy, Narrative Group, Interview 2)

A third reason that the narrative group mentioned with regard to the usefulness of the educative supports was that the supports helped them recognize that it is a part of a teacher's job to modify lesson plans. For example, Holly explained that the narratives helped her see that it is acceptable to make changes to lesson plans. She said:

> It reinforces the idea of being reflective and to not always take everything for face value. Because each time it's mainly by the teacher who's put thought into the lesson and then changed it in some way. So I just feel like you need to reinforce this idea of being reflective and not just change something. You don't have to stick to a rigid plan of whatever your school gives you or a lesson plan that you got off the internet. (Holly, Narrative Group, Interview 2)

In contrast to the narrative group, the preservice teachers in the expository group did not identify a wide range of reasons for using the educative supports, and in fact, did not cite any of the same reasons. Instead, of those who actually found the educative supports to be useful, the preservice teachers viewed the expository supports as useful for only one reason, that is, for helping them identify criteria for analyzing lesson plans. Summer described her views on the usefulness of the expository supports, saying, "I think it's another lens with which to look at lessons. So in that way I find it useful. It just raises your awareness of another aspect of the lesson to analyze" (Interview 2). Kayla expressed a similar idea: "I don't think I necessarily learned something new but just was reminded of something important we should be thinking about when teaching science" (Interview 2).

Similarly, in discussing where they got their analysis ideas within the lesson plan analysis assignments and posttests, the preservice teachers in the expository group frequently mentioned that the educative supports provided them with ideas about how to analyze science lesson plans (see Table 3). Interestingly, this was not true of the narrative group, even though more preservice teachers in this group tended to use the educative supports.

Table 3
Percentage of Preservice Teachers who Attributed their Analysis Ideas to the Educative Supports

	Assignment 1	Assignment 2	Assignment 3	Posttest
Narrative Group	12%	4%	0%	0%
Expository Group	45%	47%	47%	25%

In discussing the origin of her analysis ideas, Summer explained that part of her ideas came from the educative support, writing, "My idea for this possible change to the lesson came from the scientific principle given on the Lesson Plan Analysis assignment sheet. This principle helped

me see the importance of probing student thinking" (Summer, Expository Group, Assignment 2). Chloe also mentioned that her analysis ideas stemmed from the educative supports, writing:

> Where my ideas came from -- I used the guiding principles given with the lesson plan as a way to think about the lesson. I have noticed that each lesson plan analysis I have written for this class, I have used the guiding principles as a way to think about the lessons. At the end of the term I plan on compiling these principles and keeping them as a resource I can use later to think about and modify lessons. (Assignment 3)

In sum, these findings show that the narrative group viewed the educative supports as useful for many reasons, in contrast to the expository group who only saw the supports as useful for one purpose. However, the narrative group's views on the usefulness of the supports did not extend to the general principles themselves but instead were limited to the lesson-specific features of the educative support, whereas the expository group recognized the general principles in the educative supports as useful for helping them analyze lesson plans.

Understanding the General Principles Targeted in the Educative Supports

At the beginning of the study, the preservice teachers from both conditions did not understand the overarching principle of identifying and working with students' ideas in terms of the three general principles of practice targeted in the educative supports. Instead, the preservice teachers typically understood identifying and working with students' ideas about science to mean eliciting students' prerequisite knowledge and building instruction from those ideas so as not to waste class time teaching something about which the students already have learned. Tracy and Lily, preservice teachers from each treatment condition, illustrate this perspective on attending to students' ideas about science:

> I think you need to know what they know and where they are coming from before you can change their ideas or take their ideas further. I think that you need to kind of not like a test or whatever but kind of assess what they know or think or how they have been taught science before or what specific topics that they've learned before you can build on it or go somewhere. (Tracy, Narrative Group, Interview 1)

> I think it's one of the most important things just to figure out what they know already, because you don't want to repeat things if everybody knows the certain fact already. There's no point in going, and rehashing it for a week if they already have it. But then there are some things you will assume that they know and they don't. So if you don't know what they know already then it's hard to base where you start. (Lily, Expository Group, Interview 1)

Though eliciting students' prerequisite knowledge was the most common perspective on identifying and working with students' ideas about science, some preservice teachers also interpreted this overarching principle to mean eliciting students' interests in order to find out what students are curious about. For example, Eva exemplifies this perspective as she explained what it means to her to identify and work with students' science ideas:

> The first thing that comes to my mind I think is just students' questions that they'll have. So if they're just going about their day…and then why does this happen, or why does that

> happen? I just think that there are questions about the world around them and what their curious about. So I guess it's identifying their ideas in terms of what they're curious about. (Eva, Narrative Group, Interview 1)

By the end of the course, the majority of the preservice teachers in both conditions began to understand the overarching principle in terms of the first general principle of practice targeted in the educative supports, though not in terms of the other principles and without mention of any tracers. More specifically, many of the preservice teachers talked about identifying and working with students' ideas in terms of eliciting student thinking about the science content, including their prior knowledge and misconceptions, and designing instruction to build upon and address those ideas. For example, in response to the same interview prompt asking the preservice teachers to describe what it means to them to identify and work with students' ideas, Eva and Lily gave different responses from those described above, displaying this new understanding about the overarching principle:

> I always think of being able to identify them [students' ideas] in terms of having a free write or just an initial discussion on maybe a pre test to just see what they're thinking from the beginning and then working with them, taking them and then reading over them and then planning your lessons and your unit around the misconceptions. (Eva, Narrative Group, Interview 3)

> I think getting them out in the open so that you'll know you're all on the same playing field. And so you'll know what everybody is thinking and what they're bringing. And then trying to work them in your lesson. Whether you do that beforehand, like the day before you talk about their ideas or even at the beginning, you try to work it in while you're teaching. And thinking somehow to address their prior knowledge and their ideas in your lesson. (Lily, Expository Group, Interview 3)

These excerpts show that the preservice teachers in both conditions developed an understanding of identifying and working with students' ideas that was consistent with the ideas in one of the educative supports, though not with the ideas in all of the supports.

An exception was found to this trend in the findings. At the end of the course, a few preservice teachers in the expository group did begin to understand the overarching principle in terms of all three general principles in the educative supports. They also tended to mention the tracers from the educative supports in their descriptions. For example, Summer illustrated these new ideas as she explained what it meant to her to identify and work with students' ideas:

> I kind of talked about this before about *making thinking visible*. I'm kind of expecting at the beginning of the lesson, how is the teacher learning about students' ideas? So like in this one [lesson] the teacher asked, how are clouds made? And then, the way that the student is learning about those ideas—that would be my next question. How are the students then learning about their ideas? Also is there something with the teacher *probing student thinking* and their ideas about it? … So once you know the students' ideas, then that'll help you as you're doing this lesson in what you want to talk with them about. Especially during the assessment part, as you're helping them *make connections between their ideas that they shared at the beginning and what they've experienced in doing this activity.* You'll know

> what you want to focus on. If students say something at the beginning, an idea that was kind of contradicted in the activity, you would want to bring that to the surface and talk about it and then see again what students are taking away. (Summer, Expository Group, Interview 3, italics added to denote tracers)

Here, a preservice teacher from the expository described the overarching principle in terms of making thinking visible, probing student thinking, and constructing connections—the three principles from the educative supports.

In sum, these results show that the preservice teachers' ideas about the overarching principle did change in ways that made them more consistent with the methods course and educative supports. However, because the majority of the preservice teachers did not appropriate ideas from the second and third educative supports and did not mention any tracers, the change in their ideas may have resulted more from the methods course itself rather than from the educative supports, specifically, since the course also had a strong emphasis on identifying and working with students' ideas. However, a few preservice teachers in the expository group defined the overarching principle in terms of the three principles of practice and mentioned the tracers from the educative supports, suggesting that the change in their ideas may have resulted not only from the methods course but also from the educative supports themselves.

Use of the General Principles in the Analysis of Lesson Plans

In completing the pretest, most of the preservice teachers from both conditions did not analyze the lesson plan with regard to the general principles. In fact, they did not systematically identify strengths and weaknesses with regard to any principles at all, except for learning goals alignment, which they had learned about in their social studies methods course. Instead, as they analyzed the lesson plan, they typically started at the beginning and described what they liked and did not like about it and proceeded in this way until they reached the end of the lesson. For example, Erin illustrates this approach in the following excerpt:

> There are a number of strengths of this lesson. First of all, the lesson is very detailed. It gives very clear instruction on how to do each step, and it also clearly describes each area of the lesson itself. For example, in the materials section, the lesson is very clear as to exactly which materials should be used. I also like how the lesson includes a section called "teacher preparation" and "science background for teacher" because this helps the teacher be sure that they understand all of the scientific concepts presented in the lesson so that they are able to account for student questions and be prepared to answer them before the lesson itself. The lesson description is also very thorough, and gives suggested prompts for the teacher to ask the students. (Erin, Narrative Group, Pretest)

This approach to analysis resulted in missed opportunities to identify strengths and weaknesses in the lesson plan with regard to identifying and working with students' ideas and thus missed opportunities to modify the lesson to compensate for its deficiencies.

When the preservice teachers completed the lesson plan analysis assignments, both conditions attended to the general principle referenced in the educative supports when they received the educative support that corresponded to that principle (see Table 4). This trend was consistent for all three principles. (However, consistently fewer preservice teachers in the expository group discussed ideas related to the principle possibly because fewer preservice

teachers in this group used the educative supports, in comparison to the narrative group, as described above.)

Table 4
Percentage of Preservice Teachers Who Attended to the Principle in their Analysis Assignments

Principles	Narrative Group	Expository Group
From Assignment 1, mentioned in Assignment 1	100%	68%
From Assignment 2, mentioned in Assignment 2	72%	50%
From Assignment 3, mentioned in Assignment 3	96%	72%

However, the preservice teachers in each treatment condition attended to the principle in different ways. With regard to the narrative group, the preservice teachers did not use the educative supports to evaluate the lesson plan but instead evaluated the educative support itself. In most cases, this meant that the preservice teachers described the specific instructional approaches in the educative supports as strengths and explained why they thought it was important to follow the specific approaches. The following excerpts illustrate this use of the principles:

> A third strength in how Kendra taught this lesson includes her probing students in order to gain a better understanding of their ideas about what happens to puddles. [Kendra] realized that sometimes her students sound like they understand when they really don't. This emphasizes the importance of using 'teacher moves,' such as, 'Can you tell me more about that?' in order to gain more knowledge about student ideas. If we understand our students' thoughts about a topic, we can find ways of countering their misconceptions. (Cassie, Narrative Group, Assignment 2)

> I also liked how Kendra further probed the students thinking to have a very clear understanding of what the students' alternative ideas were, so that she could focus and guide the lesson in a way that would best address these misconceptions the students had. (Kraig, Narrative Group, Assignment 2)

Even though most preservice teachers used the narratives in this way, there were a few exceptions to this trend. Once in a while, a preservice teacher recognized the implicit principle underlying the ideas in the educative support, used it to identify strengths and weaknesses in the lesson plan, and used the fictional teacher Kendra's modifications to compensate for the lesson's weaknesses. Natalie exemplifies this alternative use of the narrative educative support as she applied the principle of constructing connections:

> …The way the lesson is set up, I think it would be hard for many students to make the connection between their model of cloud formation and what happens in the real world. Although the model is set up well, creating connections to the real world does not come until the assessment questions. Without some scaffolding, the students may not be able to explain the relationship…I think the changes that Kendra made to the lesson address my first two weaknesses perfectly. The worksheet she created does a wonderful job of scaffolding students to make the connection between their model and the real world. This is exactly the kind of thing the students need to do before they start making explanation about how clouds

> form in the atmosphere. Accordingly I would have the students do this worksheet either during their observations (in the five minute interval) or right after it. (Natalie, Narrative Group, Assignment 3)

Despite these exceptions, the preservice teachers in the narrative group tended to evaluate the educative support itself, focusing on the specific ideas in the educative support and not the general principles underlying those ideas.

In contrast, the preservice teachers in the expository group attended to the principles by using the general principle described in the educative support to identify strengths and weaknesses in the lesson plan and make modifications to improve the lesson with regard to the principle. Sophie's use of the principle 'probing student thinking' clearly demonstrates this approach to analysis:

> The main problem I see in this lesson is that the lesson does not provide a lot of opportunity for the teacher to probe student thinking plus follow up on student ideas. When the lesson begins and when Day 1 begins, there are several questions listed that the teacher can ask to see what initial ideas students have. The teacher is then expected to move on to the rest of the lesson, though, without addressing how or why students had these ideas. Part 8 on Day 2 is similar, asking students to discuss questions as a class, but never asking students to explain where their ideas came from. Finding out what ideas students have and where those ideas came from can help the teacher probe student thinking further, and see whether students really understand the science or not. This can also help teachers recognize the reasonable aspects of incorrect student ideas. A great way to improve in this way is that a few possible questions could be added during discussion times. The teacher could ask in part 1 of Day 1, 'Why do you think that?' after students share their prior ideas… (Sophie, Expository Group, Assignment 2)

Chloe also examined how well the lesson plan enabled the teacher to probe student thinking by uncovering multiple strengths and weaknesses in the lesson with regard to the principle:

> Strength - On the first day of the experiment the teacher shows the class a picture of a puddle on a rainy day, and the same picture with no puddle on a sunny day. She then asks students what happened in these pictures, what happened to the puddle, where did it go? She then records their initial ideas on a large post-it note. This part of the activity will allow the teacher to gain some insights about her student's thinking.
> Weakness -- This activity gives the teacher the opportunity to listen to her students' ideas. However, it does not give the students the opportunity to express why they have these ideas. Understanding why students have certain ideas might help the teacher better teach the lesson.
> Change -- When a student offers an explanation as to what happened to the puddle I would ask him why he thinks this. I would make a mental note in my head of the students' reasoning. I might be able to use these ideas to help the students learn the concept better…
> Strength -- On the first day when the students set up their experiment they are asked to answer questions 1-3 on their worksheet. Question 1 asks the students to explain something they did in the setup of the experiment. It then asks them WHY they did this. Question 2 asks students to make a prediction about what will happen. It then asks students WHY they think this will happen. These are two great examples of probing student thinking…

> Strength -- At the end of the experiment the teacher asks students to share their predictions about what will happen to their puddles with the class.
> Weakness -- The teacher does not probe the students as to how they arrived at their predictions.
> Change -- Simply take it one step further and ask the students why. Their responses might be very useful in leading the lesson on day 2 of the experiment. (Chloe, Expository Group, Assignment 3)

These findings show that in contrast to the narrative group, the preservice teachers in the expository group tended to intentionally use the principle in the educative support to uncover strengths and weaknesses in the lesson plan—though they varied in the extent to which they applied the principles in their analysis.

After using the educative supports, most of the preservice teachers in both conditions did not continue to attend to the principles in subsequent analyses. This was especially true for principles 2 and 3. However, some preservice teachers did continue to attend to principle 1 (making students' thinking visible) but did not intentionally apply it in their analyses. For example, most of the preservice teachers analyzed the lesson plan in a step-wise fashion, describing what they liked about the lesson from beginning to end and repeating the process for what they did not like about the lesson plan—very much like the pretest. This meant that the preservice teachers only thought about the principle of making students' thinking visible if they came across a place in the lesson plan pertaining to the principle rather than intentionally selecting the principle beforehand to use as a lens for analyzing the whole lesson. This step-wise approach to analysis often led to missed opportunities for identifying and addressing gaps in the lesson plan with regard to the principle. The following excerpt illustrates these ideas, showing how Erin began to discuss ideas related to making students' ideas visible in the posttest but did so as part of a sequential approach to analysis like in her pretest (see above):

> There are a number of strengths in this lesson. The objectives outlined show that this lesson will really help the students understand a scientific concept involving phenomena that students may have misconceptions about. By emphasizing the fact that the water does not disappear when it is heated, as many students may believe, the experiments in this lesson will help to physically show the students what actually happens when water evaporates and then condenses when it is cooled. I also like the addition to the materials, which states that you can substitute the plastic cups for cans. It is also helpful that the lesson points out to keep paper towel on hand in case there are any spills. The optional materials ideas are also helpful, and I like how the lesson states which paper towels work best for illustrating different scientific concepts. Since I think that it is very important to test out an experiment before you try to do it with your class, I think that the fact that this lesson points out the importance in testing out the experiment and the exact materials that you plan on using before teaching it. The science background for students is very thorough, and will help the teacher to understand the science behind what they are teaching. *The initial activity will help to get students thinking about the scientific concepts they will be learning about in a real world context that they may have seen in a real world context.* The learning activity also provides a nice segway into the actual lesson because the students are going to actually be observing their own glass of water. During the lesson, I like the suggestion for the teacher to do a read-aloud during the experiment so that the students are less likely to play with their cups and create a mess.

> *Finally, the whole class discussion is a nice way to find out if the students actually understand the concepts that they have seen during the experiment.* (Erin, Narrative Group, Posttest, italics added to highlight statements related to principle 1)

Other evidence for the claim that the preservice teachers did not intentionally apply the principles in their analysis of subsequent lesson plans includes the preservice teachers' descriptions of the role that the principles played in their analyses. For example, in thinking about whether she used any of the principles in other lesson plan analysis assignments, Eva explained, "I don't know if I necessarily was thinking about that [the principles] necessarily going through it. I don't know if I necessarily had it in mind from the get go that that was what I was going to look for" (Interview 2). Additionally, Sally explained that her approach to analysis did not entail applying a set of principles or lenses:

> I read it twice, and then I go through and put question marks next to things I have questions about or say, oh, I like that or maybe this will work better if you did this. Um, but no, I never take a set of lenses. (Sally, Narrative Group, Interview 3)

These findings show that the preservice teachers typically did not attend to the principles in their analysis of subsequent lesson plans, but when they did attend to the principles, they did not intentionally use the principles as criteria in their analyses.

There was one exception to this trend. A few of the preservice teachers in the expository group continued to attend to all three principles in subsequent analyses and intentionally apply them in their analysis of lesson plans. For example, Kayla described how she used the principles as criteria for analyzing lesson plans, saying:

> I read completely through the lesson plan, then came back and read this [the principle], and then I go back through the lesson plan again and first make anything that stands out to me, corrections…and then I focus on the principle for the class period, when I go back through it… I like that we have a different principle every time we do a plan because I think that otherwise, you tend to pinpoint the exact same things over and over again…. I just think it's important to step away from your own like thoughts all the time and use these when looking at it. (Kayla, Expository Group, Interview 2)

Kayla further elaborated upon her approach to analysis, discussing how she continued to use the principles from previous assignments in subsequent analyses:

> When we get these [educative supports], we have a specific lens to look at, and we didn't have anything [on the posttest], so I feel like I automatically started thinking about the lenses we used previously in the semester and that's kind of how I did it. (Kayla, Expository Group, Interview 3)

Kayla was not the only one who continued to attend to the principles and intentionally use them to analyze lesson plans. In fact, 25% of the preservice teachers in the expository group attributed their ideas to the educative supports on the posttest, whereas no one did in the narrative group (see Table 2), and many of these preservice teachers applied the principles in the posttest and even used the tracers in their analysis. For example, Nadia used all three principles to assess the

strengths and weaknesses of the lesson plan for the posttest (as well as mentioned the tracers from the educative supports):

> It [The lesson] opens the door for students to construct connections between in-class experiences and ideas about science concepts. By having them view and understand the process of condensation in their cups, they could link what they've learned to the process of condensation in clouds or dew-covered grass (however, the teacher may need to help them draw such connections, which the lesson doesn't mention.)…It doesn't directly reveal when nor how the teacher could help the students establish the connection between the experiment on condensation and condensation as it happens in other real-world phenomena. For example, no link is drawn between how condensation has occurred during the experiment and how it occurs to form clouds, fog, or dew on grass.
> -It makes the students' thinking visible ('MTV') by having them share their own views for how and why condensation occurs on the surface of the cup. This refers to both the initial question regarding the lemonade glass on a summer day and the students' beliefs regarding what had happened during the experiment.
> -It allows the teacher to probe student thinking by asking questions like 'What happens to the lemonade glass during a hot day outside?' or 'what do you think the stuff on the cup's surface is?' or finally 'where do you think it came from and how can you test your guess?' This way, the teacher could learn about what the students do and don't know about condensation, and get an idea of how to make the lesson effectively address their alternative thinking.
> (Nadia, Expository Group, Posttest)

In sum, these findings show that most of the preservice teachers began to attend to the principle when they received the educative supports corresponding to that principle, but the two groups attended to the principles in different ways. The narrative group focused on the specific ideas in the educative support but did not uncover the general principle underlying the ideas and apply it in their analysis, resulting in missed opportunities to further improve the materials with regard to the principle. In contrast, the expository group tended to use the general principle to identify strengths and weaknesses in the lesson plan and make adaptations. However, both groups rarely attended to the principles in subsequent analyses, with the exception of a few preservice teachers in the expository group who continued to use the principles in their critique and adaptation of curriculum materials. Additionally, these few individuals also used the tracers in subsequent analyses and asserted that their analysis ideas came from the educative supports, suggesting that the educative supports shaped their knowledge and skills for analyzing lesson plans by helping them identify important principles for analyzing curriculum materials.

Use of Specific Instructional Approaches in the Analysis of Lesson Plans

The narrative educative supports described how a fictional teacher adapted the lesson to address a specific problem related to the general principle targeted in the educative support. Thus, the narratives described specific instructional approaches that the preservice teachers could use to modify the lesson whereas the expository supports did not provide any such support. In examining potential differences between treatment conditions, we found that consistently more preservice teachers in the narrative group discussed the specific instructional strategies in their analysis of lesson plans when they received the corresponding educative support than those in the expository group (see Table 5). In fact, for the primary instructional approach discussed in

each narrative, two-thirds or more of the preservice teachers in the narrative group used the instructional approach in their analysis whereas only roughly a quarter of the preservice teachers in the expository support also happened to discuss the same approach. Instances of preservice teachers using the instructional approaches in their analyses are provided below.

Table 5
Percentage of Preservice Teachers Who Applied Specific Instructional Approaches

Assignment	Approach Described in Narrative	Narrative Group	Expository Group
1	Whole class discussion at beginning	88%	24%
1	Record ideas publicly at beginning	28%	11%
2	Ask probing questions	72%	29%
3	Use comparison worksheet	68%	7%
3	Revisit students' ideas	48%	25%

The narrative in the first lesson plan analysis assignment targeted the principle of making students' thinking visible and described how the fictional teacher Kendra modified the lesson to conduct a whole class discussion and record students' ideas on chart paper. In reflecting on the educative support, Cassie described that she liked both of the instructional strategies that Kendra used to improve the lesson with regard to this principle:

> I liked how Kendra, the teacher, changed the lesson and brought the whole class together after sharing in smaller groups in order to discuss their thoughts and 'make them visible' by recording in a chart. This allows the students to get a sense for other groups' ideas and to get the class thinking along the same page before jumping into the lesson and investigation. (Cassie, Narrative Group, Assignment 1)

For the second lesson plan analysis assignment, the fictional teacher Kendra modified the lesson to include guiding questions in order to probe student thinking—the principle underlying the educative support. Wendy, a preservice teacher in the narrative group, addressed this principle in her analysis by describing how she liked Kendra's modification:

> I think that one strength that I saw in Kendra's lesson modification was her intentions of wanting to probe students' thinking to understand the lesson. In probing the students to further explain their reasoning, she was able to identify that students had different interpretations and definition for the words 'disappearing' and 'evaporating.' Kendra also was able to find out students' prior knowledge and understandings of how water 'disappears.' (Wendy, Narrative Group, Assignment 2)

The narrative in the final assignment emphasized constructing connections—the third principle of practice—by describing the use of a worksheet to help students compare a model of a cloud with the real-world phenomena and revisiting students' initial ideas at the end of the lesson. Patricia picked up on both of these instructional strategies in her analysis of the lesson plan:

> I feel like both of Kendra's suggestions are needed for the original lesson plan to be effective. Providing an accompanying worksheet to have students draw and label both situations is

> helpful so they can make a visual comparison between model and actuality. This way, students are also forced to understand what goes where, as they have to consider the items they have when labeling their pictures. They may start to make connections between the two pictures at this point. Her other change was greatly needed, as well. Students should revisit the question, 'How are clouds made?' at the end of the lesson. It is so important to go back and revisit students' initial thoughts from the beginning of the lesson so they can see how their thinking has shifted, and so you can catch students who still might be unsure of what they learned. (Patricia, Narrative Group, Assignment 3)

These typical examples illustrate the preservice teachers' use of the specific instructional approaches described in the narrative educative supports.

However, even though the majority of the preservice teachers in the narrative group discussed the instructional strategies when they received the corresponding educative support, few preservice teachers continued to use the strategies from the educative supports in analyses following their use of the narratives. Table 6 shows how the percentage of preservice teachers using the specific instructional approaches described in the narrative was high when they received the corresponding educative support but greatly decreased following its use.

Table 6
Percentage of Preservice Teacher in Narrative Group that Continued to Use Instructional Approaches Described in Narratives

Principle Addressed	Instructional Approach	Assignment			Posttest
		1	2	3	
1	Whole class discussion at beginning	88%	24%	16%	20%
1	Record ideas publicly at beginning	28%	4%	0%	4%
2	Ask probing questions	0%	72%	0%	4%
3	Comparison worksheet	8%	0%	68%	0%
3	Revisit ideas	4%	0%	48%	0%

In sum, these findings show that the narratives helped preservice teachers use specific instructional approaches when they used the educative supports, but the educative supports did not appear to have any long-term impact on preservice teachers' use of the instructional approaches in analyzing subsequent lesson plans.

Discussion & Implications

The findings from this study highlight the affordances and constraints of different forms of educative support in supporting preservice elementary teachers' analysis of lesson plans and thus have implications for science teacher education and the design of educative curriculum materials. These results provide insights into how to support preservice teachers in developing beginning levels of expertise in critiquing and adapting curriculum materials and how to develop educative supports that support teacher learning.

The results indicate that the preservice teachers in the narrative group tended to focus on the lesson-specific features of the narrative educative supports. This focus enabled the preservice teachers to identify and apply specific instructional approaches in their analyses and see why they were important. It also helped them see the supports as useful in many ways, motivating them to use the narratives in their analysis assignments. However, the lesson-specific nature of

the educative supports made it difficult for the preservice teachers to recognize the general principle underlying the ideas in the supports. Thus, they did not view the ideas in the educative supports as useful for critiquing the lesson plan as a whole or for analyzing other lesson plans. Additionally, in completing their analysis assignments, the preservice teachers did not use the general principle to guide their analysis of the curriculum materials, resulting in missed opportunities to further improve the materials beyond the suggestions in the educative support.

In contrast, the preservice teachers in the expository group tended to focus on the general principle in the educative support. This focus enabled the preservice teachers to see the support as useful for analyzing the lesson plan. It also enabled them to see that the usefulness of the educative support extended beyond the specific lesson plan itself, helping them see the educative support as a resource for learning how to analyze lesson plans, more generally. Additionally, in completing the analysis assignments, the preservice teachers identified strengths and/or weaknesses in the lesson plan with regard to the principle and made relevant adaptations. However, because the expository educative supports were not embedded within the context of a specific lesson, they did not help the preservice teachers identify specific instructional approaches related to the principles that they could use in their analysis. Additionally, the preservice teachers possessed limited views on the usefulness of the educative supports, with some not seeing the educative supports as useful at all. This limited view on the usefulness of the supports resulted in some preservice teachers choosing not to use the supports in their analyses.

These results have implications for the design of educative curriculum materials. In order to help teachers see how the ideas in an educative support are relevant to a specific lesson, curriculum developers need to embed the educative supports within the context of a lesson, like how the narratives were designed in this study. Contextualizing support for teachers may help them see the educative support as useful and thus motivate them to actually read the support and use it in their practice. Additionally, lesson-specific supports that explain how and why teachers should use particular instructional strategies may help teachers identify beneficial instructional approaches to use with their students as well as understand why they are pedagogically useful and appropriate (Ball & Cohen, 1996; Davis & Krajcik, 2005; Remillard, 2000; Schneider & Krajcik, 2002). On the other hand, in order to help teachers see how the lesson-specific ideas in an educative support relate to a more general pedagogical idea, curriculum developers need to make the general principle of practice underlying those ideas explicit to the teacher, like how the expository educative supports were designed in this study. This may help teachers to identify important pedagogical principles for analyzing lesson plans as well as see how the ideas in the educative supports might be relevant to other lesson plans.

These results also have implications for science teacher education. In order to help preservice teachers identify important criteria for analyzing lessons, teacher educators need to provide opportunities for preservice teachers to learn about new pedagogical principles that represent important ideas about teaching and learning. This will help preservice teachers expand their ideas about effective science teaching. Additionally, these pedagogical principles need to be explicitly linked to lesson plan analysis tasks in order to help preservice teachers see how these principles can help them think about substantial strengths and weaknesses within curriculum materials (Davis, 2006; Gunckel et al., in review; Schwarz et al., in review). On the other hand, in order to help preservice teachers see what these pedagogical principles look like within lesson plans, teacher educators need to allow preservice teachers to examine curricular examples that attend to the principles of practice as well as examine materials that fail to attend to the principles and illustrations of how the weaknesses may be addressed. This type of support may

help preservice teachers think thoughtfully about specific aspects of lesson plans and develop their skills for critiquing and adapting curriculum materials.

In examining long-term impacts of the educative supports on preservice teachers' knowledge and skills for analyzing lesson plans, this study found that most preservice teachers in both conditions did not continue to attend to the ideas in the educative supports, including the principles and instructional approaches, in subsequent analyses. They also did not come to understand the task of identifying and working with students' ideas in terms of all three general principles of practice. Why might have this been the case? The preservice teachers in the expository group may have needed additional exposure to the pedagogical principles in the educative supports in order to help them change the *cueing priority* for these ideas (Smith, diSessa, & Roschelle, 1994). Preservice teachers come to instruction with several ideas about how to analyze science lesson plans (Davis, 2006; Gunckel et al., in review; Schwarz et al., in review). Therefore, in order to help them add new ideas to the mix or prioritize some ideas over others, they may need several opportunities to use the same principles in analyzing different lesson plans in order to help the preservice teachers cue these new ideas in more contexts and thus ultimately increase their cueing priority over time.

With regard to the narrative group, the preservice teachers did not recognize the general principle in the educative supports and thus may not have seen the ideas in the educative supports as generalizable to other lesson plans. Additionally, they did not use the instructional strategies in other analyses possibly because in some cases the strategies may not have been relevant or in other cases the preservice teachers simply may not have recognized that the strategies could be applied to other lessons. For these reasons, the preservice teachers may have benefited from having the general principle be made explicit in order to see that the lesson-specific ideas were grounded within a more general principle of practice. Additionally, like the expository group, the preservice teachers may have needed more than one opportunity to apply each principle and instructional strategy in their analysis of curriculum materials. This would have allowed them to think about the same principles and instructional strategies using different lesson plans, possibly helping them to see how the ideas in the educative support were applicable to other contexts and giving them practice in applying the ideas using different lesson plans.

Even though the educative supports had little long-term impact on both treatment conditions, a few preservice teachers in the expository group continued to use the principles (along with the tracers) in their critique and adaptation of curriculum materials. They also attributed their analysis ideas to the educative supports and began to understand the task of identifying and working with students' ideas in terms of the three pedagogical principles. These findings suggest that the expository educative supports shaped some preservice teachers' knowledge and skills for analyzing lesson plans by helping them develop a deep understanding of what it means to attend to students' science ideas and identify important principles for analyzing curriculum materials.

Again, these findings contribute to the field's understanding of how to design science teacher education programs and educative curriculum materials in ways that support aspiring and beginning teachers, respectively, in developing beginning levels of proficiency in critiquing and adapting curriculum materials. Teacher educators need to provide preservice teachers with repeated scaffolded experiences targeting the same principles of practice in order to help them learn how to identify and apply important pedagogical principles in their analyses. Similarly, curriculum developers need to embed educative supports targeting the same set of principles across multiple lesson plans in order to provide teachers with opportunities to see the same

principle illustrated in different contexts. This may, in turn, allow teachers to identify important principles of teaching, understand how they can be applied to specific lessons, and develop the understanding and skills for knowing when and how to use these ideas in new contexts.

This study sheds light on many questions regarding how to support preservice teachers in becoming well-started beginners in analyzing curriculum materials and how to design educative curriculum materials to support teacher learning. However, other questions still remain. While the results from this study suggest that preservice teachers would benefit from educative supports that include both lesson-specific and general features, additional studies are needed to determine what can be learned from such supports. In particular, what are preservice teachers' views on the usefulness of these educative supports? How do they use them in their analysis of lesson plans, and what do they learn from? What is the quality of preservice teachers' analyses when provided with such support? How do preservice teachers' knowledge and beliefs about science teaching and learning mediate their interactions with the educative supports? What other features of educative supports may support them in learning how to critique and adapt lesson plans? While this study did not examine inservice teachers' interactions with educative supports, the field would also benefit from studies examining how inservice teachers use and learn from different types of educative supports embedded within curriculum materials. Additionally, this study shed light on the need to find ways to sustain changes in preservice teachers' analyses. How do preservice teachers' ideas and skills change with repeated opportunities to use educative supports targeting the same principles? Addressing these questions and others will further illuminate how educative supports can support preservice and inservice teachers as they engage in curricular design making.

In sum, this study illustrates the need to support preservice teachers in developing the professional knowledge and skills for critiquing and adapting curriculum materials. Teachers educators need to find ways to build upon the strengths of preservice teachers while also helping them overcome the challenges that they encounter as they engage in these teaching tasks (Davis, 2006; Grossman & Thompson, 2005). Additionally, curriculum developers need to make thoughtful decisions about how to design educative supports to promote teacher learning (Ball & Cohen, 1996; Davis & Krajcik, 2005). Embedding strong examples of educative support within curriculum materials will help beginning teachers continue to learn about curriculum materials analysis through their experience as teachers.

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Appendix A

Educative Supports from the Second and Third Lesson Plan Analysis Assignments

Educative Supports from the Second Lesson Plan Analysis Assignment
Expository Educative Support
General Principle: Teachers need to identify, interpret, work with, and support students' ideas to help students make sense of the science. Specific Principle: Teachers need to probe student thinking. Students have a range of ideas about scientific phenomena. Some of students' ideas are based on their experiences in the natural world and their perceptions of those experiences. Others develop from things their parents, teachers, or peers have told them in the past. These ideas influence how students learn new ideas. Therefore, it is important to probe student thinking. This means to find ways to uncover and interpret students' ideas by providing opportunities for students not only to state WHAT ideas they have but also WHY they have particular ideas. Why is this important? Probing student thinking helps teachers assess student understanding. Students may provide the teacher with answers they want to hear or may sound like they understand but really don't. Therefore, unpacking students' ideas helps teachers determine if students really understand a concept or not. Probing student thinking also helps teachers recognize what's reasonable about students' ideas. Sometimes ideas sound off-the-wall, but once a teacher digs deeper, the teacher can see where the idea came from and see that it makes a lot of sense in certain situations. Knowing where or how students have developed particular ideas can help teachers have a better idea about how to work with them to help students move toward a more accurate understanding of the science.
Narrative Educative Support
When Kendra taught this lesson, she wanted to make sure she probed her students' thinking to understand it. She began the lesson by showing the before/after puddle pictures and asking the students, "What happened to the water in the puddle?" Some students said that the water had soaked into the soil while other students said they thought the water had disappeared. To get a better idea of why they held these ideas, Kendra decided to further probe student thinking. She followed up her initial question with questions like, "What do you mean by that? Can you tell me more about that? Why do you think that is the case?" Kendra found out that the students who thought the water soaked into the ground had seen water soak into soil. She also found out that some other students really thought that the water was gone forever, not that the water had simply gone into the air. And for good reason, since all of their experiences pointed to the water "disappearing." Kendra was glad that she continued to probe students' thinking. She realized that sometimes her students sound like they understand when they really don't. She also realized how reasonable her students' ideas were even though they might not be scientifically accurate. Finally, by probing student thinking, Kendra was able to find out why her students held particular ideas. This information helped her know what instructional strategies she might use to help her students examine and refine their thinking during the investigation.

Educative Supports from the Third Lesson Plan Analysis Assignment

Expository Educative Support

General Principle: Teachers need to identify, interpret, work with, and support students' ideas to help students make sense of the science.

Specific Principle: Teachers need to help students construct connections between in-class experiences and ideas about science concepts.

In-class experiences can involve direct experience with real-world phenomena and/or models or representations of phenomena. While these experiences can provide powerful learning opportunities, students may not see how in-class experiences connect to their ideas and may not use these experiences as opportunities to examine and build upon their initial ideas. Therefore, it is important to help students construct connections between in-class experiences and their ideas about science concepts. This means to find opportunities to help students make sense of in-class experiences and examine and refine their initial ideas in light of what they learn from these experiences.

Why is this important?

Helping students construct connections between in-class experiences and their ideas about science concepts enables students to see the similarities and differences between in-class experiences and the real world. They might not see these on their own, but with support, they can do so—making the in-class experiences a much more powerful learning opportunity.

Helping students construct connections between in-class experiences and their ideas about science concepts also enables students to use the new ideas that they've learned from their in-class experiences to examine and refine their initial ideas about a science concept. This will help students develop a more accurate understanding of the science.

Narrative Educative Support

Kendra taught this lesson last year, but she struggled with helping students construct connections between the model and their ideas about clouds. Kendra realized that she needed to first help her students see how the model was similar to and different from the real world. So this year, she made a worksheet for her students. On one side, she wrote "My Investigation: Draw and label your model. Use the words puddle, air, salt, and water droplets." On the other side, she wrote, "Clouds in the Real World: Draw and label how clouds are formed. Use the words pond, air, particles, and water droplets." Kendra was glad she used the worksheet because it helped her students see how the components of the model were connected to actual clouds in the real world—one aspect of constructing connections. After helping students understand the model, Kendra felt like her students were ready to construct connections between their in-class experiences and their initial ideas about cloud formation. She decided to have them revisit the question she posed at the beginning of the lesson. She asked, "Based on your results from this investigation, is there anything you'd like to add to or change about your ideas about how you think clouds are made?" To make sure students understood how clouds are formed, she asked students to give evidence from the investigation model. By helping students construct connections between their in-class experiences and their ideas about science concepts, her students could use the new ideas they had learned through class experiences to examine and refine their initial ideas about how clouds are formed.

Appendix B
Interview Protocols

Interviews 1 & 3

I. Probing Understanding of the Principles

1. One of the main goals in the science methods class is to help you learn how to identify and work with students' ideas about science. What comes to mind when you think about students' initial ideas about science? What comes to mind when you think about what it means to identify and work with students' ideas about science?
2. Do you think as an elementary science teacher that it will be important to learn about your students' ideas about science? Why do you think this?
3. Imagine you are a 3rd grade teacher entering your first year of teaching and that you are going to teach a unit on plants. Before beginning the unit, let's say you want to find out what ideas your students have about plants. How would you find out what ideas your students have about this concept? Why do you think this would work?
4. What kinds of ideas do you think your students might have about plants? (Besides misconceptions, are their other ideas that you think they might have?)
5. What would you do to find out *why* your students have this particular idea? Why do you think this would work?
6. Once you've found out what your students' ideas are about plants, what would you do with their ideas (if anything)? Why?
7. If you found out that your students had particular misconceptions, how might you help your students modify their ideas? Why do you think this would work?

II. Discussion of Pre/Posttest

1. In looking at this homework assignment, what main ideas did you focus on in your analysis? *For each main idea, ask:* Why do you think this idea is important?
2. (Interview 3 only) What big changes do you see in how you evaluated this lesson at the beginning of the semester with how you evaluated the lesson at the end of the semester? Why do you think your ideas have changed?
3. The science methods course focuses a lot on identifying and working with students' ideas about science. Without actually evaluating the lesson [from the pre/posttest], what sorts of things would you look for if you were to analyze this lesson plan based on how well it helps you as a teacher identify and work with students' ideas about science?
4. (Interview 3 only) The next set of questions deal with your views about the strengths and weaknesses of the lesson plan with regard to the [educative supports] from the previous lesson plan analysis assignments. With regard to (making students' thinking visible/probing student thinking/constructing connections betweens tasks & kids' ideas),
    a. What does this statement mean to you?
    b. What do you think are the strengths of this lesson (if any) with regard to this idea, and why? What do you think are the weaknesses of this lesson (if any), and why?
    c. Where did you get your ideas with regard to these concepts?

Interview 2

I. Discussion About How They Completed the Lesson Plan Analysis Assignments

1. When you completed the third lesson plan analysis assignment, what steps did you take to complete the homework assignment? *Probes:*
    a. Did you read through the documents multiple times?
    b. What order did you read the documents?
    c. How did you keep track of your thoughts? Did you take any notes?
    d. Did you use the story [or principles] as you analyzed the lesson? If so, in what ways? If not, why?
2. Is this how you typically have approached the lesson plan analysis assignments?
3. In class, I know you've talked some about examining curriculum materials using different lenses or perspectives. In looking at this lesson plan, what kinds of lenses did you use in your analysis? *For each lens mentioned, ask:* Why did you choose that lens?
4. Was the [educative support] useful in thinking about the assignment? If so, in what ways? If not, why?
5. Do you feel like you have learned anything from reading this lesson plan? From reading the [educative support]? From evaluating, critiquing, and adapting this lesson plan?

II. Think Aloud

I'd like for you to read aloud the lesson plan and [educative support] from your homework assignment. As you read these documents, you'll periodically come across red asterisks. At these points in the reading, I'd like for you to stop and tell me what you are thinking about with regard to what you just read.

III. Discussion of Third Lesson Plan Analysis Assignment

1. In your science methods course, you've been thinking a lot about how to identify and work with students' ideas about science. If you were to evaluate the lesson based on how well it incorporates ways to identify and work with students' ideas about science, what sorts of things would you look for in the lesson plan?
2. Next, I would like for you to think about these ideas as you evaluate the lesson plan that you used in your previous homework assignment. In evaluating this lesson plan…
    a. What would you say that you like (if anything) about how this lesson helps teachers identify and work with students' ideas? Why do you think this?
    b. What would you say that you dislike (if anything) about how this lesson helps teachers identify and work with students' ideas? Why do you think this?
    c. How would you change the lesson (if at all) to address the weaknesses you just described? Why do you think these changes are important?
    d. Where did you get your ideas about students' ideas in thinking about the strengths, weaknesses, and changes you'd make to the lesson plan?

Appendix C
Coding Scheme for All Data Sources

Code	Sub-Code	Description
Understanding of Principles	Make thinking visible	Preservice teachers discuss ways to make students' ideas explicit by providing opportunities for students to communicate their ideas to teachers and/or peers.
	Probe student thinking	Preservice teachers discuss ways to uncover and interpret students' ideas by providing opportunities for students not only to state WHAT ideas they have but also WHY they have particular ideas.
	Construct connections	Preservice teachers discuss ways to create opportunities to help students make sense of in-class experiences and examine and refine their initial ideas in light of what they learn from these experiences
	Elicit student interest	Preservice teachers discuss ways to find out what interests students have about a particular topic.
	Elicit prerequisite ideas	Preservice teachers discuss ways to uncover students' prerequisite knowledge about a science topic.
Tracers	Assignment 1 tracers	Make student' thinking visible; Make students' ideas visible; MTV
	Assignment 2 tracers	Probe students' thinking.
	Assignment 3 tracers	Construct connections
	Tracers specific to narrative group	Story, pink sheet, Kendra
	Tracers specific to expository group	Yellow sheet, principle
Use of Educative Supports	Read supports	Preservice teachers read the educative supports.
	Not read supports	Preservice teachers do not read the educative supports.
	Discuss rationales	Preservice teachers discuss rationales mentioned in educative support.
	Discuss strategies	Preservice teachers discuss the instructional strategy mentioned in the educative support
	Relate principles	Preservice teachers relate the principle to their personal experiences as learners and teachers.
	Apply principles	Preservice teachers use principle as a criterion in their analysis by finding strengths and/or weaknesses in the lesson plan related to the principle and making relevant lesson modifications.
Views on Usefulness of Educative Supports	Visualize lesson	To illustrate what the lesson would look like in practice.
	Address problem	To address a specific problem with the lesson as well as helping them.
	Modify lesson	To recognize that it is okay to modify lesson plans.
	Identify criteria	To identify criteria for analyzing lesson plans
Instructional Approaches	Whole class discussion (from principle 1)	Have students share their ideas with the whole class at the beginning of the lesson.
	Record ideas publicly (from principle 1)	Record students' ideas/predictions/observations/findings for the whole class to see.
	Ask probing question (from principle 2)	Ask follow up questions that probe students' surface ideas, like "What do you mean by that? Can you tell me more about that? Why do you think that is the case?"
	Use worksheet (from principle 3)	Use a worksheet/chart that helps students articulate the similarities and differences between a model (in-class experience) and the real world.
	Revisit students' initial ideas (from principle 3)	Revisit the opening question posed at the beginning of the lesson, for example, by asking, "Based on your results from this investigation, is there anything you'd like to add to or change about your ideas?"
Origin of Ideas	Science methods class	Ideas come from class discussions, readings, etc.
	Other education classes	Ideas come from other education classes besides science methods.
	Science learning	Ideas come from experiences learning science as a student.
	Student learning	Ideas come from experiences as a student, in general.
	Educative supports	Ideas come from educative supports in lesson plan analysis assignments.

	CT/Classroom Observations	Ideas come from conversations with cooperating teacher and/or from observing classroom instruction in their field placement.
	Teaching experience	Ideas come from their own experiences teaching lessons.
	Teacher sense	Ideas come from visualizing the lesson and thinking like a teacher.
	Thinking like a student	Ideas come from thinking about how students may experience lesson.