EXAMINING PRESERVICE ELEMENTARY TEACHERS' PLANNING PRACTICES IN SCIENCE

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Planning is a crucial aspect of preparing for successful teaching. Teachers plan for the lessons that they teach, however the extent to which they do this varies. Because preservice elementary teachers (PSETs) need to learn how to plan for several different subjects, their planning practices as well as their depth of content knowledge in a subject like science may not be adequate. Teaching a discipline like science requires not only an understanding of the factual information that is typically associated with such a subject, it also requires an understanding the content as well as of the types of practices used in science to build upon existing knowledge. Lesson plans that meet these requirements utilize a reform approach to teaching so that phenomena are explored before explanations are given. Additionally, all selected tasks clearly align to prescribed lesson Learning Goals so that disciplinary practices and content are present during instruction. Seventy-two PSETs created lesson sequences from a set of ten tasks to teach the concept of the density of solid objects that were provided by their science methods instructors. The task sequences were examined for two purposes: to determine if PSETs intended to use a reform or traditional approach to teaching; to examine the capabilities of PSETs to align prescribed Learning Goals to instructional tasks and their capacity to do this accurately. Findings indicate that while PSETs state that their aim is to create task sequences that make use of a reform approach to teaching, via the Learning Cycle, a traditional approach is used most often (i.e., explain before explore). In addition, while PSETs can generally select tasks that have the potential to meet all of the prescribed Learning Goals, they struggle to align content-grounded Learning Goals to the tasks that they select with accuracy. The findings for this study have implications for science teacher educators and for science teacher education.

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PREFACE

There are many people that I would like to thank for supporting my work at the University of Pittsburgh over the last five years.

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1.0 THE RESEARCH PROBLEM

1.1 BACKGROUND

If teachers around the world have anything in common, it just might be that they recognize the need to plan for the lessons that they intend to teach (So, 1997). In addition, whereas they may all recognize the need to plan, the lesson plans that teachers generate in preparation for instruction look quite different from teacher to teacher, district to district and state to state (Brown, 2009; Ding & Carlson, 2013). That being said, learning how to write a lesson plan is a common component of any instructional methods class in a teacher preparatory program, regardless of the grade level or subject-specific discipline (Ding & Carlson, 2013; McLaughlin & Calabrese Barton, 2012).

This suggests then, that planning is an integral part of teaching all subjects, including science. Without proper planning, the instruction that occurs in the classroom during lesson enactment may not be adequate for supporting students as needed (So, 1997). Likewise, without proper planning, teachers may not fully realize the intended learning goals for the days' lessons. As a result, instructional time is lost and opportunities are missed to build content knowledge for a given subject (Davis, Pettish & Smithey, 2006). So then, if adequate planning for classroom instruction is a necessity, one might ask, "What do you *need* to plan for?"

The answer just might be, "Everything."

1.2 PREPARING PSETS TO TEACH SCIENCE

Preparing Pre-Service Elementary Teachers (PSETs) to teach science is no small feat. While teachers do receive support for teaching science through the curriculum materials supported by their school districts and their enrollment in a science methods course during the teacher preparation program, there are several obstacles that they face. First, science lesson plans do not look like lesson plans for other subjects. This shift in lesson formatting is challenging for PSETs to grasp, primarily because they do not understand the processes and practices associated with doing science (Davis, Pettish & Smithey, 2006; Forbes, 2011; Mikeska et al., 2009; Ross & Cartier, 2015). Additionally, PSETs often lack an adequate grasp of science content knowledge (Davis & Krajcik, 2005; Davis Pettish & Smithey, 2006; Ding & Carlson, 2013; Ross and Cartier, 2015; Schwartz et al., 2008). Insufficient content knowledge can keep PSETs from thinking about the types of tasks that need to be present during science lessons and from carefully deciding why they should be there (Shulman, 1986). An inability to scrutinize the tasks they are planning to teach can easily lead to the likelihood of a mismatch in what PSETs intend to teach, and what ends up being taught (Mikeska et al., 2009; Ross & Cartier, 2015; Schwartz et al., 2008). If lesson goals are not carefully aligned to instructional tasks that teachers plan to teach, student achievement in science may be restricted. In addition to limited instructional time for teaching science, this may keep PSETs from having adequate experiences for planning to teach this vital subject.

1.3 EXAMINING PSETS' SCIENCE PLANNING PRACTICES

Researchers continue to address two particular areas in which PSETs struggle with planning science lessons: First, the instructional approach utilized for teaching science, and second, the ability to develop lesson plans that possess the capacity for meeting the learning goals that are identified by the curriculum. When PSETs prepare to teach science, these two areas lay the foundation for the type of instruction that will occur in the classroom and the opportunities that students will have to interact with disciplinary knowledge.

These two building blocks lay the foundation for teaching science in the classroom, regardless of the grade level. PSETs are beginning teachers of science; they need exposure to planning practices, disciplinary practices, and task affordances so that they can make instructional decisions that are appropriate and well-informed.

1.3.1 Instructional approach to teaching science

Research showed that PSETs often had a narrow understanding of what it meant to do science. They often made use of a traditional approach to planning and teaching this subject, which meant that they provided explanatory information about a topic before they allowed students to explore phenomenon. While PSETs typically welcomed hands-on activities in their science lessons, it was well-documented that when these types of tasks were selected it was because they were viewed as being “fun” and familiar, and had predictable outcomes (Appleton & Kindt, 2002). Tasks of this type rarely provided elementary students with opportunities to engage with science in a way that was realistic or authentic because the result was known, and science challenged us to understand more about what we know.

Science educators therefore, encouraged PSETs to develop lessons that engaged students' minds as well as their hands (Bianchini & Cavazos, 2007; Davis, Pettish & Smithey, 2006; Mikeska et al., 2009; NRC, 2007; Ross & Cartier, 2015). This meant that a reform approach to teaching was supported. When a reform approach to teaching was employed, students were given the opportunity to observe and explore what was happening during an investigation without knowing the result. Students used what they noticed during the investigation to explain what they thought was happening. Teaching science using a reform approach mirrored science done in a laboratory or in the field: asking a testable question, generating a protocol for gathering data, collecting and recording data, organizing and representing data to find patterns, explaining the results of your investigation.

This was complex work. It required careful planning on the part of the teacher and an understanding of disciplinary practices in science, such as collecting and organizing data for the purpose of identifying patterns and trends, and a firm grasp of both factual and conceptual disciplinary knowledge (Mikeska, Anderson & Schwartz, 2009). Traditional investigations that merely verify what is already known do not emulate the work of science. The instructional approach employed by PSETs in the science lesson plans that they wrote determined how their students experienced and engaged with this subject.

1.3.2 Aligning prescribed learning goals to lesson tasks

A second area that challenged PSETs when they planned and prepared to teach science was working to determine that there was clear alignment of prescribed learning goals (LGs) to the recommended instructional tasks (Mikeska, Anderson & Schwartz, 2009; Ross & Cartier, 2015). PSETs were not to presume that tasks present in curriculum materials would meet prescribed

LGs for a given lesson. Likewise, they were not to presume that tasks could simply be replaced when they were unfamiliar or appeared to be more complex. PSETs were to carefully examine the LGs and the tasks of published curriculum materials during the planning process in order to ensure that students would have an opportunity to engage with and grasp disciplinary content during science instruction.

A critical analysis with scrutiny of tasks in the published curriculum materials was an essential component of elementary science teacher education. Work of this type supported PSETs in their efforts to understand specific science content as well as disciplinary practices. (Brown, 2009; Forbes, 2011, 2013; Mikeska et al., 2009; Ross & Cartier, 2015; Schwartz et al., 2008). The goal was to encourage PSETs to interact with curriculum materials so that they were certain that instructional time was used to address specific LGs.

While task selection was important for every subject, task selection and the sequencing of chosen tasks determined the instructional approach of a lesson and the likelihood of students to engage with prescribed LGs. Not all tasks were useful at all times, and PSETs needed to evaluate the capacity of a given task to ensure that it aligned to the LGs.

1.4 STUDY OVERVIEW

The purpose of this study was to further explore PSETs' planning practices when given a final assignment that asked them to envision a lesson sequence in science on the topic of density. This topic was chosen intentionally because of its common association with sinking and floating in elementary classrooms. Density is an intrinsic property of matter and can be used to identify a uniform solid object as being similar to, or different from, another similar uniform solid object.

Ten tasks that addressed density were provided. Most addressed density of solid objects, while a few addressed the density of both solids and liquids. PSETs were asked to select tasks from those provided and place them in a sequence that they felt would allow them to address the four prescribed LGs.

There were two areas that this research study examined. First, the task lesson sequences that PSETs developed for the final assignment in a science methods course were explored to determine what type of instructional approach – traditional or reform – were used. The task sequences were examined along with explanations that PSETs provided regarding their reasoning for how they ordered the tasks. The findings were used to determine how the tasks and the intentions of the PSETs to use the tasks compared.

The second area that was examined dealt with PSETs' abilities to select tasks that met the prescribed LGs for the lesson sequence. Instructional tasks are everywhere: they are in published curriculum materials, they can be found on the Internet, and sometimes a teacher will recall a task that they used when they were in an elementary science class. While tasks come from various sources, PSETs needed to have opportunities to think about what it meant to ensure that a selected task would meet LGs. They needed to selectively choose those that addressed the intended LGs that were supported by the curriculum and standards. Additionally, they needed to think about the types of tasks that supported fact-based LGs and content-grounded LGs, as not all tasks met both types of goals.

While planning was the prelude to successful action, it was not easy for PSETs to write science lesson plans. Experiences in science methods courses supported the challenges that they faced and provided them with opportunities to consider not only what to plan, but when to plan for it.

2.0 LITERATURE REVIEW

Adequately planning to teach an elementary science lesson can be a complex process (Grossman, et al., 2009). Teacher educators must therefore support Pre-service Elementary Teachers (PSETs) while they are enrolled in science methods courses so that they are prepared to do this work successfully. PSETs know that elementary students enjoy science and its hands-on appeal, however they hesitate to teach this subject because of their own limited understanding in this domain. Yet a solid grasp of what it means to do science can help PSETs to not only make better decisions about how they will teach the topics they cover, but also to ensure that learning goals are met through the tasks chosen by the teacher.

This chapter will address what it means to do science in the elementary classroom and the instructional supports that can assist PSETs in making choices about their approach to teaching this subject. Additionally, this chapter will examine the relationship between lesson learning goals (LGs) and tasks selected for instruction during the lesson planning phase. Finally, I will explore the current research base that describes what is known about the planning practices of PSETs when they are preparing to teach science. The recommendations provided will be used to assist in framing my research questions.

2.1 DOING SCIENCE

Teaching science is unlike teaching other subjects. While most other subjects can be planned from a teacher-centered perspective, where the teacher is the source of knowledge, information or direction, science does not fit this approach (Goldston et al., 2010; Levine, Hammer & Coffey, 2009). As a discipline, science is learner-centered, meaning that the ideas and inclinations of the learner need to be considered in order to determine purpose and direction (Levine, Hammer & Coffee, 2009). This is because when we engage with science, we work to better understand what we know and to acquire more knowledge in an area (Davis, Pettish & Smithey, 2006). Additionally, the type of work that is done during a science lesson is specific to what it means to do science. Disciplinary practices, such as, asking testable questions and collecting data are essential components of this effort (NRC, 2012). Tasks that support these types of practices need to be present in lesson plans so that students have the opportunity to participate in science authentically, or in ways that mirror what is done daily in labs and in the field (Ding & Carlson, 2013; Ross & Cartier, 2015).

2.1.1 The nature of science

As stated above, science is a discipline unlike other subjects taught in the elementary classroom. According to the American Association for the Advancement of Science, the phrase, nature of science, "involves the basic values and beliefs that make up the scientific world view, how scientists go about their work, and the general culture of the scientific enterprise" (2001, p15). More recently, the Next Generation Science Standards have defined science as "a way of explaining the natural world. It is both a set of practices and the historical accumulation of knowledge" (2013, vol.2 p96).

The information in Table 1 is a foundational part of the way in which science views its work. For example, one of the basic understandings about the nature of science is that "science is a human endeavor" (NGSS Lead States, 2013, vol.2 p97). This means that everyone, regardless of age, sex, background, or education level, can participate in doing science. Most people don't always feel this way however. Oftentimes people, young and old, feel that because they aren't scientists in an official capacity, they cannot conduct science investigations. Nothing can be further from the truth. We all have the ability to wonder about the world in which we live, therefore, we have the power to design and develop and conduct experiments to understand and know more.

Table 1. Nature of Science (NOS) Matrix (NGSS Lead States, 2013, vol.2, p97)

	The basic understandings about the nature of science are:
•	Scientific investigations use a variety of methods
•	Scientific knowledge is based on empirical evidence
•	Scientific knowledge is open to revision in light of new evidence
•	Scientific models, laws, mechanisms and theories explain natural phenomena
•	Science is a way of knowing
•	Scientific knowledge assumes an order and consistency in natural systems
•	Science is a human endeavor
•	Science addresses questions about the natural world and material world

This suggests that the basic understandings of the nature of science are present in our daily lives. Children and adults engage with these understandings regularly as they seek to know more. Children in particular often have a seemingly insatiable thirst for information. Teachers can make the decision to plan science lessons that support the nature of science so that students become active participants in their own learning. Teachers can also make the decision to tell students what they know about a topic in science or conduct an experiment that they are familiar with to verify this knowledge (Schwartz et al., 2008). The decisions made during the lesson planning process by teachers and PSETs can determine how genuinely students are able to engage with and understand the nature of science.

2.1.2 Science practices

Research shows that PSETs lack a firm grasp of the nature of science (Davis, Pettish & Smithey, 2006) As such, they typically choose to plan to teach science in ways that are similar to their own elementary experiences with science (Bianchini & Cavazos, 2007; Ding & Carlson, 2013; Mikeska, Anderson & Schwartz, 2009). Because PSETs are unfamiliar with science processes they are also uncertain of the types of science practices that occur in the discipline (Forbes, 2011). It is this combination of disciplinary processes and practices that help to define and describe the work that is done in science.

Table 2. Science Disciplinary Practices (NRC, 2012, p42)

• **asking questions**
• **developing and using models**
• **planning and carrying out investigations**
• **analyzing and interpreting data**
• **using mathematics and computational thinking**
• **constructing explanations**
• **engaging in argument from evidence**
• **obtaining, evaluating, and communicating information**

As with the basic understandings of the nature of science, when disciplinary practices are omitted from science lessons in the elementary grades, it is quite possible that students are not actually engaged with doing science. According to the National Research Council (NRC), students participating in science investigations should have opportunities to do specific types of work in order for their efforts to be considered the work of science. During science classes students should: collect or examine data, analyze the data in search of patterns, and then generate representations of the data to explain the presence of the patterns (2007, 2012). Table 2 lists all of the practices identified by the NRC that students of science should be doing when they are engaged in a science lesson on any given topic. While students may not engage with all of these practices during a single science lesson, a combination of two or three of these practices should be present in any science lesson that a teacher has planned for students (NRC, 2012).

Science pervades our world. The scientific process as well as the practices associated with it are an undeniable part of what it means to conduct science. For the purposes of this study the nature of science and the disciplinary science practices are elemental concepts that should underlie decisions made during the planning process. Teacher educators need to support PSETs' understanding of the nature of science and the disciplinary science practices in the elementary science methods courses. A firm grasp of this information can help to ensure that PSETs make informed choices about the approach they plan to use to teach science and the types of tasks that they select to ensure that students are participating with science (Davis, Pettish & Smithey, 2006; Mikeska, Anderson & Schwartz, 2009).

2.2 PLANNING TO DO SCIENCE

Planning for science instruction is complex. It requires forethought and insight into the nature of science and the disciplinary science practices that support scientific understanding (Ding & Carlson, 2013). While PSETs are often interested in teaching science, they often lack the skills and insight needed to ensure that lessons emulate the work of science. Teacher educators are therefore responsible for providing PSETs with opportunities to: better understand the nature of science, interact with disciplinary practices in science, and explore curriculum materials that are currently in circulation in elementary classrooms.

2.2.1 Instructional approach

Science lessons can be taught in a variety of ways. When teachers plan for teaching science they do not always know how to plan in a way that reflects their beliefs about how this subject should be taught (Bianchini & Cavazos, 2007; Davis, Pettish & Smithey, 2006). As a result, their planning practices may not clearly reveal their intensions for a given lesson. Therefore, teacher educators need to think about what they can do to support PSETs that teach a variety of subjects in the elementary grades, so that science lesson plans indicate an instructional approach that is akin to science.

2.2.1.1 Traditional approach to teaching science

Recall that most subjects are planned using a teacher-centered approach to instruction. Lesson plans in subjects other than science is to direct the actions of the teacher as she proceeds with instruction (Goldston et al., 2010; Levin, Hammer & Coffey, 2009). This means that the teacher is the primary source of knowledge. Lessons plans that are teacher-centered are considered to traditional in their approach to teaching. The expository nature of traditional lesson plans revolves around the progressive actions of the teacher as she provides further information to the students on the topic.

When science lessons are planned using a traditional approach, the teacher, as the knowledge source, provides explanatory information to students up front (Davis, Pettish & Smithey, 2006). She may provide them with factual information such as the number of earth years it takes to equal one year on the planet Jupiter, or she may share technical terminology along with definitions. Likewise, formulas that can be used to determine exact measurements, along with the expected outcome of an impending experiment may be provided before students begin to work. This is characteristic of a traditional approach to teaching science; teachers explain before they allow students to explore.

2.2.1.2 Reform approach to teaching science

While a traditional approach to teaching science does not support the nature of science nor the disciplinary science practices a reform approach to teaching science does (Schwartz, 2008). This is because when a reform approach is used for planning to teach science, students are given opportunities to explore scientific concepts, phenomenon and ideas before this information is explained to them. When science lessons are planned using a reform approach, students participate in tasks that utilize disciplinary science practices. Additionally, students are exposed to the nature of science because they are more familiar with what it means to do the work of science.

Science lesson plans that incorporate a reform approach to instruction do not position the teacher as the source of all knowledge and information. Rather, lessons that utilize this type of approach have the students working to acquire information so that they can explain what they think is happening based on what they have observed and noticed. This instructional approach is more authentic because students are conducting investigations in much the same way that scientists in labs and in the field do.

The Learning Cycle

The Learning Cycle is an instructional framework that can be used by teachers during the planning process so that they might better organize their instruction. The Learning Cycle framework naturally encourages the inclusion of the disciplinary science practices recommended by the NRC because of the focus on what the students should be doing in each phase of this framework (Carlson, 2015). Frameworks such as the 5-E Learning Cycle (see Table 3), give teacher educators and PSETs a common structure that can be used when planning and modeling how to teach science.

There are a couple versions of the Learning Cycle: the 5-E Learning Cycle (Bybee, 1996), the 7-E Learning Cycle (Bentley, Ebert & Ebert, 2007). For the purpose of this research study I am using the 5-E Learning Cycle (see Table 3) and I am looking most carefully at the first three phases of this framework: Engage, Explore, Explain. In particular, I am interested in the Explore and Explain phases. This is because lessons that use a traditional approach to teaching place the Explain before the Explore, while lessons that use a reform approach to teaching place the Explore before the Explain.

Table 3. Summary of the BSCS 5-E Instructional Model (Bybee, 2002, p. 125)

Phase	Summary
Engage	The instructor assesses the learners' prior knowledge and helps them become engaged in a new concept by reading a vignette, posing questions, doing a demonstration that has a non-intuitive result (a discrepant event), showing a video clip, or conducting some other short activity that promotes curiosity and elicits prior knowledge.

Table 3 continued

Explore	Learners work in collaborative teams to complete lab activities that help them use prior knowledge to generate ideas, explore questions and possibilities and design and conduct a preliminary inquiry.
Explain	To explain their understand of the concept, learners may make presentations, share ideas with one another, review current scientific explanations and compare these to their own understanding and/or listen to an explanation from the teacher that guides the learners toward a more in-depth understanding.
Elaborate	The learners elaborate their understanding of the concept by conducting additional lab activities. They may revisit an earlier lab and build on it, or conduct an activity that requires an application of the concept.
Extend	The evaluation phase hopes both learners and instructors assess how well the learners understand the concept and whether they have met the learning outcomes.

2.2.2 Learning goals and tasks

Science lessons plans are often based on predetermined learning goals (LGs) and therefore, the tasks that accompany these LGs are also prescribed (Remillard, 2005). When teachers read over lesson LGs and tasks, they begin to determine how they will engage with these important pieces of their lessons (Brown, 2009). The interactions between teachers and the lessons that they teach vary. Regardless teachers recognize that their objective is to support students in understand the LGs through the tasks that have been provided.

2.2.2.1 Learning Goals

Learning Goals (LGs) represent the knowledge that teachers want their students to leave the instructional lesson understanding. Some LGs are fact-based, meaning that the knowledge that they represent is relatively unchanging. For example, two fact based LGs that are connected to understanding lunar cycles include: From earth, we experience the moon rising in the east and setting in the west. From earth, we always see the same side of the moon. Both of these statements represent facts about the moon. As facts, this information remains consistent over time and so it would be surprising to make observations that are counter to these facts.

While some LGs are fact-based, other LGs are conceptual and therefore grounded in science content. LGs that are conceptual provide explanatory knowledge about why something happens. In order to be able to explain a concept in science, students need access to information that is more than a collection of facts. When explaining a concept, students need to have an opportunity to make observations, gather data and look for patterns in the data so that they can potentially give a reason for the presence of the patterns (Mikeska, Anderson & Schwartz, 2009). These types of activities are part of the disciplinary practices of science and fit nicely into the explore phase of the Learning Cycle.

We work to understand science concepts more so than we work to memorize them. This means that grasping a concept fully may take a lifetime. Fortunately, not all concepts require such a time commitment. For example, the idea of a “cycle” as being part of a repetitive, predictable process, can be generalized, and applied to various situations. If we revisit the lunar cycle example above, one of the fact-based statements says that from earth, we always see the same side of the moon. Supposing that this is true, why is this the case? If we are only able to view one side of the moon from earth, then the moon is rotating on its axis. While the moon is visible in different phases and at different time of the day, we still see just this one side regardless. This means that the moon is in synchronous rotation with the earth. In other words, as the moon revolves around earth it rotates just once on its axis. Therefore, we view the same side of the moon regardless of its phase.

Science concepts are derived from fact-based information as well as observations that we make, data that we collect, and patterns that we notice. Explanations in science are complex. While fact-based information helps to support science explanations, additional information is needed to be able to sufficiently describe why something is happening.

2.2.2.2 Tasks

Like LGs, tasks are often provided by the curriculum materials with which teachers work (Remillard, 2005; Schwartz, et al., 2008). Tasks vary in their complexity and the type of information for which they provide access. Curriculum materials offer tasks as a way to mobilize the LGs for a lesson (Mikeska, Anderson & Schwartz, 2009). For their part, teachers examine tasks and interpret them so as to determine the task's purpose in the lesson (Ding & Carlson, 2013). This interpretation may or may not be accurate depending on the teacher's capacity to think about the intention of the task in relation to the Learning Goals and the needs of the student learners.

Tasks offer different experiences to their student learners. Additionally, they place different demands on the teacher. Some tasks have students verifying statements made by the teacher or the textbook in which they use. For example, in a chapter that discusses lunar cycles, the text book may state the fact that we see the same side of the moon regardless of the phase that it is in or the time of day that we see it. To verify this, the teacher may then provide the students with pictures of the moon in its various phases. She may then go on to explain to the students that they can see consistent features on the surface of the moon regardless of the phase, so this must mean that we always see the same side of the moon. To conclude the teacher may ask the students to point out features that they see on several images of the moon. Tasks that are organized like this explain information to students before they are able to make observations on their own.

Some tasks allow students to make observations and draw conclusions from what they see before explanations are asked for or given. These types of tasks require teachers to have information or materials prepared and available to students for examination so that they can think about what they want to describe and how they want to describe it. In addition, the teacher needs to have a clear understanding of the conclusions that students should make as they observe the materials and discuss what they notice. A task on lunar cycles that supported this type of work would have students examining photos of the moon in order to notice similarities and differences in the pictures. The teacher would ask the students to share what they observed and think about why might see these similarities and differences in the pictures. The teacher might either choose to share the fact that we always see the same side of the moon, or she might decide to help the students come to this conclusion based on their observations. Regardless, the students are exploring the images of the moon for the purpose of locating similarities and differences before they are given or asked to provide an explanation. The explanation is provided or confirmed only after the students have had an opportunity to think about the concept themselves.

2.3 PSETS' PLANNING PRACTICES IN SCIENCE

Science teacher educators are well aware that there are many challenges that PSETs face when it comes time for them to plan elementary science lessons. PSETs generally lack an understanding of the nature of science and they are typically unfamiliar with the types of disciplinary science practices that need to be included in their science lessons (Davis, Pettish & Smithey, 2006; Goldston et al., 2010; Mikeska, Anderson & Schwartz, 2009; Ross and Cartier, 2015). When PSETs are left to figure things out for themselves, they frequently rely on their own past experiences with science and use these as a basis from which to proceed in their planning (Ding & Carlson, 2013). This can be problematic because they may misinterpret the intent of tasks and investigations, perhaps even removing them from a lesson and potentially eliminating the science from the science lesson.

2.3.1 Instructional approach

Several research studies have worked to explore the tendencies of PSETs regarding their instructional approach as they prepare to teach science. While some things appear to be consistent in various settings, we have learned that there are some types of interventions that seem to influence PSETs' planning practices in positive ways. Additionally, recommendations have provided insight into what may better support PSETs' efforts so that their intentions come across during instruction

PSETs tend to embrace reform practices from their methods classes when they plan science lessons. However, they often struggle to do this effectively and accurately (Davis, Pettish & Smithey, 2006; Mikeska, Anderson & Schwartz, 2009). Recall that a traditional approach to instruction provides students with an explanation of the concept before they have the opportunity to explore related ideas, phenomenon or patterns; explain-then-explore. A reform approach to instruction offers students the opportunity to explore ideas, phenomenon and patterns so that an explanation might be developed from what they have noticed in the exploration process; explore-then-explain.

Forbes (2011) and Schwartz et al., (2009) both recommend that in order to better support PSETs in their efforts to plan science lessons that utilize a reform approach to instruction, teacher educators need to provide PSETs with opportunities work with authentic, reform-minded curriculum materials. Schwartz found that PSETs were more likely to use reform-minded curriculum materials when they aligned with their own goals for the planned curriculum (2009).

Forbes found similar tendencies in that PSETs often find difficulty when attempting to translate their own ideas about science instruction into reform-minded instructional approaches (2011). Both authors felt that focused experiences with curriculum that already adhered to a reform approach to teaching would be better choice for supporting PSETs in their efforts to plan in this way.

Oftentimes curriculum materials are not positioned in a way that supports a reform approach to teaching. When this occurs, an instructional framework, such as the Learning Cycle, can be used to guide PSETs' planning practices in science. Because elementary teachers are generalists and need to be prepared to teach all subjects, instructional frameworks such as the Learning Cycle can be used to bolster planning efforts (Goldston et al., 2010). The Learning Cycle positions instructional experiences, and therefore tasks, in a way that provides students with opportunities to explore concepts through disciplinary science practices. Activities such as, data collection, development of models, and justification of claims are all part of what it means to engage with and participate in doing science (Mikeska, Anderson & Schwartz, 2009)

Teacher Educators are therefore situated to help PSETs understand science and the types of practices that define what it means to do science. Recall that PSETs teach multiple subjects in their elementary classrooms (Davis, Pettish and Smithey, 2006). In order to help PSETs understand what it means to do science, teacher educators should provide PSETs with focused opportunities to develop their skilled practice in teaching science (Grossman et al., 2009) Teacher educators need to provide PSETs with access to current curriculum materials for the purpose of analyzing them to ensure that they utilize a reform approach to instruction (Schwartz et al., 2009). Teacher educators can then help PSETs to identify authentic teaching practices in science and give them the opportunity to engage with planning to teach science (Forbes, 2011; Ross & Cartier, 2015)

Working to plan for instruction can also help PSETs to better understand the problems of practice that exist in science education and teacher educators are positioned to help with this (Schwartz et al., 2009). For example, in the elementary classroom the school bell often drives the activities of the day. When the bell rings, students change classes. Science investigations don't always go as planned and adhering to rigorous time constraints can certainly cause problems when students are working in ways that mirror science. Teacher educators can provide PSETs with insight into challenges like this so that they can make informed planning decisions. Additionally, allowing PSETs to anticipate student engagement in science lessons that support a reform approach to teaching can give them further awareness into authentic teaching practices for this subject (Mikeska, Anderson & Schwartz, 2009).

2.3.2 Aligning learning goals to tasks

Deciding what to teach in science class is not always a simple process. The difference between tasks that are just fun and tasks that are genuinely provide opportunities to participate in doing science cannot always be easily ascertained. PSETs need to learn how to select tasks so that they are able to teach lessons that contain focused content that students can grasp upon completion of the lesson via disciplinary science practices (Davis & Krajcik, 2005).

While elementary science curriculum materials are generally full of investigations and tasks for student to try, it should not be presumed that the investigations and tasks recommended by the curriculum are aligned to the prescribed learning goals for any given lesson. Therefore, when PSETs are preparing for science lessons, they need to determine whether or not a task will support students in achieving lesson learning goals (Rivet & Krajcik, 2008; Ross & Cartier, 2015). If they should determine that a task will not be adequate, then they either need to adapt the task or remove it from the lesson and replace it with a task that is better suited.

`Working with curriculum materials is part of the work of teaching. Brown (2009) addressed teachers' pedagogical design capacity and described the ways in which teachers mediate or actively engage with the curriculum materials that they are expected to utilize in their teaching. Part of the work that teachers need to do while scrutinizing the curriculum is to determine whether or not the tasks and activities prescribed by the curriculum will actually meet the learning goals of the lesson (Mikeska et al., 2009; Ross & Cartier, 2015; Schwartz et al., 2008).

This endeavor is challenging for PSETs for several reasons. First, curriculum materials are often lacking in supporting materials for teachers (Davis and Krajcik, 2005). This means that when teachers look through the recommended lesson and accompanying activities to create their lesson plans, they may not readily understand why these particular activities have been included in the intended lesson. Their lack of experience in addition to their lack of content knowledge could leave them guessing as to whether or not the prescribed activity is appropriate for the next day's lesson.

This initial challenge can potentially lead to the next; selecting tasks because they are favored by the teacher due to known or predictable outcomes and are seen as having a high level of fun where the students are concerned. Appleton & Kindt (2002), as well as Schwartz et al. (2008) address these issues in the discussion sections of their research. Both articles found that PSETs resisted using planning framework documents and teacher guides to help them select appropriate tasks for instruction. Instead they chose tasks that "they thought would work"

(Appleton & Kindt, p50) because “a teacher just knows what will work” (Schwartz et al., p369). While we do want to develop PSETs abilities to engage with elementary science curriculum materials, we also want them to make informed decisions about any changes that they make (Mikeska et al., 2009; Ross & Cartier, 2015). Referring to the list of Science Practices (Table 2) or consulting an instructional framework like the Learning Cycle (Table 3), can help to support PSETs in their planning and appropriation of tasks. Both of these resources can help PSETs to determine if the task is serving a purpose in assisting students as they work toward comprehension of a science learning goal, or if the task is simply smoke and mirrors and therefore has no depth.

A third reason that PSETs struggle to align instructional tasks to lesson learning goals is that they have difficulty determining the level of quality around the recommended curriculum materials. (Mikeska et al., 2009; Schwartz et al., 2008). When teachers engage with curriculum materials, one of the things they have to do is determine whether or not they feel a task will meet the lesson goals. If they feel that the task is suitable, then it is likely that they will utilize it in their lesson plans. If they feel that a task is inadequate, they may modify the task in order to improve it. It is also possible that the teacher could omit the task completely and replace it with a task of her own selection based on past experiences teaching similar lessons. PSETs do not have the same well of resources that experienced teachers do. As a result, it is difficult for PSETs to adequately evaluate curriculum prescribed tasks to determine if they are adequate or not. Additionally their abilities to modify existing tasks or select new, better aligned tasks are lacking.

2.4 RESEARCH QUESTIONS

Question #1: What does the sequence of tasks that PSETs select tell us about their approach to teaching science?

1a: What approach, reform or traditional, do PSETs take when creating a science lesson sequence?

1b: When PSETs created science lesson sequences that reflect a traditional or reform approach, what are the reasons they give for the tasks they select?

1c: When traditional or reform approach is used, how does the capacity of the task sequence PSETs created compare to what PSETs say they want the task sequence to do?

Question #2: What do the tasks that PSETs select tell us about how they understand and address the prescribed Learning Goals?

2a: Do PSETs satisfy the Learning Goals in the science lesson sequences they create?

2b: From the PSETs' perspective, what Learning Goals do they address in the tasks they select?

2c: When selecting tasks to address the Learning Goals, how do the Learning Goals that the PSETs think they are addressing compare to Learning Goal capacity of the tasks they are selecting?

3.0 METHODOLOGY

3.1 OVERVIEW OF THE CHAPTER

This is a descriptive study that aims to better understand the instructional choices PSETs make when planning a series of lesson tasks for elementary level science classes following a 15-week science methods course. This study investigates PSETs' capacity for using an instructional approach grounded in reform methods, and their ability to attend to specific instructional learning goals (LGs) as they select and sequence tasks that they believe would address the goals. Data for this study came from one primary source: The Task Selection & Sequencing tool (TSS). The TSS was developed as part of a NSF-funded project (Jen Cartier, Principal Investigator). The nature of this informal tool provides multiple opportunities for both quantitative and qualitative data analysis due to the fact that PSETs were responding to prompts in a variety of ways.

The remainder of this chapter describes the research questions, the instructional setting and the methods for this research study. I begin by providing a description of the context in which this study was conducted. Next, I share the instructional framework used exclusively for teaching and planning in the course, discuss the participatory experiences in which PSETs were engaged, and describe the aforementioned TSS tool. Subsequently, I describe my role in this study as both the classroom instructor and the researcher. I continue by describing the participants and their experiences in the MAT program. Finally, I explain how the data analysis procedures support each of the research questions.

3.2 RESEARCH QUESTIONS

Question #1: What did the sequence of tasks that PSETs selected tell us about their approach to teaching science?

1a: What approach, reform or traditional, did PSETs take when creating a science lesson sequence?

1b: When PSETs created science lesson sequences that reflected a traditional or reform approach, what were the reasons they gave for the tasks they selected?

1c: When traditional or reform approaches were used, how did the capacity of the task sequences PSETs created compare to what PSETs said they wanted the task sequences to do?

Question #2: What did the tasks that PSETs selected tell us about how they understood and addressed the prescribed LGs?

2a: Did PSETs satisfy the Learning Goals in the science lesson sequences they created?

2b: From PSETs' perspective, what Learning Goals did they address in the tasks they selected?

2c: When selecting tasks to address the Learning Goals, how did the Learning Goals that PSETs think they were addressing compare to the Learning Goal capacity of the tasks they were selecting?

3.3 THE CONTEXT: ELEMENTARY MASTERS OF ARTS IN TEACHING PREPARATORY PROGRAM

The context for this study was a year-long elementary teacher preparatory MAT program offered at a large Midwestern public university in the United States. All of the students enrolled in this program held a bachelors degree, most in an area such as Psychology, Business, Communications, and Liberal Arts. The students were placed at local elementary schools in grade level classrooms for the entirety of the school year in which they were enrolled in the MAT program. Students spent their days at their school sites, while their evenings were spent taking methods courses at the University. The methods courses satisfied state-mandated hourly requirements for various subjects so that the students could achieve certification. The elementary science methods course was fifteen weeks in duration and was taken during the fall semester.

3.3.1 Learning Cycle as a model for planning to teach reform-based elementary science

The 5-E Learning Cycle (LC) has been used as an instructional framework in reform-based science instruction for over 20 years (Bybee, 1997, 2002; Goldston, Day, Sundberg & Dantzler, 2009; Ross & Cartier, 2015; Settlage, 2000). [See Table 4: Summary of the BSCS 5-E Instructional Model, which describes the phases of the Learning Cycle in further detail.] The Learning Cycle has five phases of instruction: Engage, Explore, Explain, Elaborate, and Evaluate.

During the Engage phase of the Learning Cycle, teachers work to activate students' prior knowledge and motivate students to want to learn more about an interesting topic. The teacher determines the depth of the students' understanding regarding the topic while also gauging their level of interest. During the Explore phase of the Learning Cycle, students explore phenomenon related to the topic of interest. Students work with data that they gather on their own, or with data that is provided to them, so that they can focus on locating patterns in the data. During the Explain phase, students explain patterns that they notice in the data, and they use representations that they created to do this. Continuing on, the Elaborate phase of the Learning Cycle is when students investigate the topic in order to deepen their understanding. Finally, during the Evaluate phase Learning Cycle, the teacher assesses the students' comprehension of ideas and concepts through further application of the conceptual lesson goals and formative or summative assessments.

Table 4. Summary of the BSCS 5-E Instructional Model (Bybee, 2002, p. 125)

Phase	Summary
Engage	The instructor assesses the learners' prior knowledge and helps them become engaged in a new concept by reading a vignette, posing questions, doing a demonstration that has a non-intuitive result (a discrepant event), showing a video clip, or conducting some other short activity that promotes curiosity and elicits prior knowledge.
Explore	Learners work in collaborative teams to complete lab activities that help them use prior knowledge to generate ideas, explore questions and possibilities and design and conduct a preliminary inquiry.
Explain	To explain their understand of the concept, learners may make presentations, share ideas with one another, review current scientific explanations and compare these to their own understanding and/or listen to an explanation from the teacher that guides the learners toward a more in-depth understanding.
Elaborate	The learners elaborate their understanding of the concept by conducting additional lab activities. They may revisit an earlier lab and build on it, or conduct an activity that requires an application of the concept.
Extend	The evaluation phase hopes both learners and instructors assess how well the learners understand the concept and whether they have met the learning outcomes.

The Learning Cycle framework is a preferred instructional model for teaching reform-based science lessons for several reasons: it promotes the nature of science and the scientific process, it allows teachers to gain access to students' prior knowledge, and it provides teachers and students with the opportunity to assess the degree to which the content-guided LGs of the lesson have been met. The aim of my study is to understand 1) the choices made by PSETs in selecting and sequencing tasks that, in turn, determine the instructional approach that they take to teaching science, and 2) the abilities of PSETs to attend to lesson goals using these selected tasks in the lesson sequence.

The Learning Cycle was modeled and supported throughout the elementary science methods course to support a reform approach to teaching science. When a reform approach is used to teach science, participants have the opportunity to consider what they know about a given topic before they are guided through exploratory experiences and hear explanations from the instructor. This is often referred to as the explore-then-explain approach to teaching science. A traditional approach to teaching science works in a way that is opposite of reform. Students participating in science instruction that uses a traditional approach are told why or how a phenomenon occurs so that fact-based LGs related to the topic are exposed and explained right away. Sometimes the students are given a follow-up lab activity, observation task or demonstration exercise to verify the factual knowledge that was explained to them. This is often referred to as the explain-then-explore approach to instruction and is indicative of a traditional approach to teaching science.

3.3.1.1 Pedagogical cycles of instruction around the Learning Cycle

Instructors of the Elementary Science Methods course encouraged the use of this instructional tool (the Learning Cycle) by PSETs during the course in two distinctive ways: first, by modeling what instruction and learning looked like when using the Learning Cycle, and second, by working carefully with PSETs as they wrote their first science lessons using the Learning Cycle framework. I describe the instructional experiences here and the planning aspect in the following section.

There were two instances during the 15-week semester when the PSETs actively participated as learners in the 5E Learning Cycle. The Earth-Moon-Sun Learning Cycle began during the first week of the methods course and lasted for three weeks. This experience was designed to help PSETs to better understand the importance of data collection and data interpretation for the purpose of explanation of phenomena (NRC, 2007a, 2007b). During classroom meetings, PSETs discussed their data set, determined the types of patterns that they noticed in their data, and attempted to create physical models to explain or emulate these patterns.

The second 5E Learning Cycle experience PSETs engaged with had to do with the Kinetic Molecular Theory of Water. In this Learning Cycle, PSETs used first-hand data collection from their methods course, prior knowledge about phenomena related to the water cycle, and knowledge of the behavior of particles of matter in solid, liquid, and gaseous phases. Students used patterns they noticed in the first-hand data to describe why solid water takes up more space than liquid water. They created visual representations to explain their observations. Finally, the students explained the Kinetic Molecular Theory of Water using the knowledge that they acquired from the investigation.

Following both Learning Cycle experiences, the instructors encouraged PSETs to reflect on their work. The instructors wanted PSETs to consider the benefits of using the Learning Cycle framework when planning so that lessons included tasks that made use of authentic science practices. Additionally, they wanted PSETs to experience for themselves how participation in these practices (gathering data, looking for patterns, representing the patterns, explaining the patterns) supports students as they work to explain scientific phenomenon.

3.3.1.2 Planning for instruction by way of the Learning Cycle

During the second half of the semester, PSETs wrote a detailed 3-E Learning Cycle Lesson plan (Engage, Explore, Explain). This assignment was designed to provide PSETs with the opportunity to think carefully about how to plan for elementary science lessons that made use of the methods and instructional approaches that were modeled during their course work. The purpose of the assignment was twofold: instructors wanted to give PSETs a chance to work with the beginning phases of the Learning Cycle framework in a practical sense, and they wanted to do this while still providing instructor support by offering feedback on lesson drafts.

3.3.1.3 The Task Selection & Sequencing (TSS) assignment

The focus of this study was a task assigned to PSETs at the end of the semester: Task Selection & Sequencing (TSS). This was a Take-Home Exam that was used to assess their ability in making practical use of the knowledge that they acquired over the course of the term with regard to planning and teaching science. It is important to note that there was no mention of the Learning Cycle or any of the other teaching practices that were covered during the course when the TSS was introduced. I describe the assignment briefly here. A complete copy of the TSS, in addition to the ten tasks associated with it, can be found in Appendix A.

The TSS required PSETs to design and plan a lesson sequence for 5th grade students around the topic of density. The instructors provided PSETs with a primer on density during class just prior to distributing the TSS materials, in order to support their content knowledge on this topic in a general sense. When PSETs received the TSS, they were also provided with the instructional components for the lesson sequence, information about 5th grade students' prior knowledge and skills around the instructional components, and ten tasks on density (see Appendix A, p. 5).

To be clear, the instructional components for this assignment included both the Big Idea and the Learning Goals for this planned lesson. This means that PSETs were given the overarching concept that their lesson sequence should address, as well as the instructional goals that should be met by students. Table 5 contains the instructional components for this task.

Table 5. Instructional Components for TSS Exam

Big Idea	All objects are made of matter and can be characterized according to their properties. Some properties, such as color and volume, are specific to objects. Other properties, such as density and conductivity, are specific to the material kinds (types of matter) that make up those objects
Learning Goal #1	Objects can be characterized in terms of the property of density. Density is a measure of the amount of matter contained in a given space.
Learning Goal #2	We measure the amount of matter in terms of mass. And we measure the space an object takes up in terms of volume
Learning Goal #3	All uniform solid objects made of the same material will have the same density regardless of their particular volume, mass, shape, or color. Therefore, density is a property of material kinds, not just of particular objects
Learning Goal #4	Calculate an object's density using the ratio of mass to volume (d = m/v).

The ten tasks that were given to the students each dealt with density to a certain degree. Some focused on the formula for density: d = m/v, while others conceptualized the idea of density – that density is a measure of the amount of matter packed into a given space. Others tasks had students collecting data on the mass and volume of an unknown solid substance so that they could use this information to discuss which solid object they felt would be most dense based on a comparison of the data. There were even some tasks that had the students looking at the density of solid objects in water, as well as examining the densities of two or more liquids in relation to one another. [Note: these tasks that examined liquid densities were related to the LGs of this lesson but were distractor items in this assignment. The reasoning is that the behavior of solid objects in water is also affected by buoyancy, which was NOT a learning goal in this particular lesson.]

The primary data sources for this investigation were the task sequences that PSETs created as they worked to complete the TSS Exam as their final assignment in the course. The objective of the Take-Home Exam was that PSETs plan a task sequence on density using as many or as few of the ten tasks provided. The PSETs were told that they could sequence the tasks they selected in whatever order they felt would best provide the students with the opportunities needed to meet the LGs for the assignment. PSETs were directed to work alone, but they were able make use of any of the materials that the instructors had provided to them during the 15-week class. Furthermore, they were asked to save an electronic response sheet to their computers so that, as they selected each task, they could respond to three questions that further described their selections: 1) Why did you select this task/activity?, 2) What modifications or additions did you make to this task/activity?, and 3) Why did you place this task/activity here in the instructional sequence?

3.4 ROLE OF THE RESEARCHER

My role during the collection of data used for this study was as one of the two course instructors; therefore, I helped with the design and development of the course over multiple semesters. Additionally, I was permitted to create tasks for PSETs enrolled in the course. Thus, I played two sequential roles on this project: instructor and researcher. When I served as the instructor, I had not anticipated that I would be acting as the researcher.

3.5 PARTICIPANTS

PSETs were placed in elementary classrooms, kindergarten through 5th grade, for the year in which they were enrolled in the MAT Elementary Certification program. Most PSETs were placed in traditional, public-school classrooms. They had access to Full Option Science System (FOSS) science kits in their grade-level classrooms. A handful of PSETs were placed in the university lab school, a private, public school, that did not have a formal science curriculum. PSETs at both types of placements had science instruction, but to varying degrees. Typically, those placed in the traditional public-school classrooms observed science being taught a few times a month. Language arts and mathematics lessons made up most of the days' work, so science was taught when time allowed. Those PSETs placed in the university lab school saw science being taught a few times a week. Additionally, the curriculum was teacher-created and often centered around the interests of the students in the classroom. While no formal curriculum existed at the lab school, science classes were part of the weekly teaching schedule.

Exposure to an array of instructional materials like FOSS kits and online science lessons helped to support and challenge their use by PSETs in the elementary classroom. While FOSS kits were dominated by hands-on activities, their relationship to LGs was not always apparent. Likewise, online resources were usually not well-supported by other materials and LGs were often missing or vague at best; you can find hundreds of thousands of activities on the life cycle of a butterfly using a Google search. Selecting tasks purposefully to ensure that prescribed LGs were met was a core practice of planning to teach science. Exploring FOSS kits as well as Engineering Is Elementary (EIE) kits and online activities provided all PSETs, regardless of the experiences in their placements, with opportunities to examine published and unpublished curriculum materials. PSETs needed to learn how to scrutinize the tasks, in spite of their source, to ensure that the tasks they selected and planned to teach had the capacity to meet the prescribed LGs.

The participants in this study were in two cohorts of Elementary MAT PSETs (see Table 6). They were all enrolled in the Elementary Science Methods course during the fall semester of their professional year. Participants in both of these cohorts were in their early to mid-twenties and had obtained a bachelor's degree in an area other than science. Eighty percent of the participants in both cohorts were female, and ninety-seven percent were Caucasian. There were two African-American females, one from each cohort.

Table 6. Participant Groups

Cohort	Section	Participants
Fall 2009	Wednesday	21
Fall 2010	Wednesday	21
	Thursday(a)	17
	Thursday(b)	14
		Total n = 73

3.6 CODING AND ANALYSIS OF SUBMITTED TSS EXAMS

This section will describe the processes and coding tools that I used to code the data for analysis in this study. A second coder coded a subset of the data to establish reliability in coding the qualitative data (Miles, Haberman & Saldana, 2014). To ensure reliable coding of the information located in the TSS Exams, the second coder coded 20% of the data for each of the questions I am addressing in my study. The primary coder trained the secondary coder on using the coding definitions and tools. In double coding the data for both questions and all of the sub-questions we were able to achieve an interrater reliability of 78%. Where we disagreed, we subsequently discussed our coding decisions and reached a consensus.

To help ensure reliable coding of the data from the TSS Exam, the secondary coder had access to the same de-identified exam responses as the primary coder. The secondary coder used a random number generator to determine which 14 of the 72 exam responses she would code (20%). The secondary coder was familiar with the Science Methods course in which the TSS Exam was utilized; she taught a section of the course in the Fall semester of 2012.

3.6.1 Analytic tools

I have developed levels of coding in order to evaluate the data embedded in the TSS Exam responses from the PSETs. The lesson sequences that they created for this assignment share more than just an order for teaching selected tasks. PSETs shared with us why they selected tasks, any modifications that they would make to the tasks they chose and their rationale for placing a task in a certain position in the sequence. As a result, my research questions grew out of my interest in the themes that seemed to rise to the surface repeatedly as PSETs responded to these prompts in their TSS Exam submissions.

3.6.1.1 Coding analysis for Research Question 31

In order to answer Research Question #1 – (What did the sequence of tasks that PSETs selected tell us about their approach to teaching science?) – I analyzed the data to respond to the three sub-questions related to the task sequences that PSETs created for the TSS Exam. The approach of their task sequences was first evaluated only by noting the tasks they had selected and the order in which they had placed them. Next, the modifications that PSETs made to the selected tasks were carefully read to determine if they changed the intent of the task such that the capacity of the task was altered. If the capacity of a task was altered, then the initial evaluation of the task sequence regarding instructional approach might differ from the preliminary assessment. In that case, the task sequence was reexamined to determine if the original evaluation of approach was the same or if it had changed. Finally, the primary task sequence approach evaluation (responses to question 1a) was compared with the secondary task sequence approach evaluation (responses to question 1b) and a matrix was used to illustrate the approach PSETs used when developing their task sequences from the perspective of the tasks alone and from the perspective of PSETs via their task modifications.

Question 1a: What approach, reform or traditional, did PSETs take when creating a science lesson sequence?

Table 7. Instructional Approach Codes

Code	Definition/Description
Ref – Reform Approach	Students that used a reform approach in creating their lesson sequence will have a task that offers students the opportunity to **explore** phenomenon by taking measurements, gathering data, noticing patterns, and comparing samples placed **before** they have a task that **explain**s any of the concepts around the focal topic, density, such as defining terms like, mass, volume and density and/or having students calculate density using the mathematical formula d=m/v
Trad-N-R – Traditional Approach **Explain then Explore**	Students that used a traditional approach in creating their lesson sequence will have a task that **explain**s the concepts around the focal topic, density, including providing definitions for mass, volume, density and/or having students calculate density using the mathematical formula d=m/v **before** they have a task that **explore**s phenomenon around density, such as taking measurements, gathering data, noticing patters and comparing samples.
Trad-N-N – Traditional Approach **Explain then Explain**	Students that used a traditional approach in creating their lesson sequence will have a task that **explain**s the concepts around the focal topic, density, including providing definitions for mass, volume, density and/or having students calculate density using the mathematical formula d=m/v they **then** they have another task or series of tasks that **again explain**s concepts around density
Other	Students use a sequence of tasks that do not appear to have either a reform or traditional approach.

Coding procedure:

- Read through task sequences created by PSETs.
- Use the TSS Accurate Sequence Function/Activity Alignment Matrix (See Table 7) to determine if PSETs use a Reform or Traditional Approach, based on the sequence of the selected tasks.

- Read through PSETs' descriptions of any modifications they would make to tasks/lessons they selected.
- Use PSETs' Perceived Instructional Approach Results (see Table 8) to display how many PSETs from the sample utilize each of the approach options.

Table 8. TSS Accurate Sequence Function/Activity Alignment Matrix

Engaging Tasks (Hook – motivating learners to want to find out about the topic; Explicitly connecting to PK)	Purple	Orange	Green	Pink	
Exploring Tasks (Descriptive; investigate the topic by collecting first or second hand data; to identify patterns)	Yellow	Gray	Blue	Purple	Brown
Explaining Tasks (Developing an explanation or a model that can account for patterns previously identified)	Black Yellow	Red Gray	Orange Brown	Green	Pink
Distractor Tasks (Liquid State tasks that compared density of liquids and density of solids in liquids)	Blue	Purple	Brown		

Question 1b: When PSETs created science lesson sequences that reflected a traditional or reform approach, what were the reasons they gave for the tasks they selected?

Table 9. Coding Definitions for Task Selection

Code	Definition/Description
G – Engage	Task is selected for the purpose of engaging students, perhaps by activating prior knowledge or motivating students to want to know more about the task or the topic.
R – Explore	Task is selected because students will have the opportunity to compare density of solids, compare solids in liquids (sink or float), compare density of liquids to liquids, compare the density of solids to gases and liquids. Tasks in this category also allow students to take measurements, gather data, and look for patterns.
N – Explain	Task is selected because the teacher wants to be certain that students know and are familiar with the meanings/concept of terms/vocabulary such as mass, volume, density and/or matter. Calculating density using the formula d = m/v is also a way to explain the density of a substance.
A – Apply	Task is selected to provide students with the opportunity to practice a skill set such as measuring mass or volume. Tasks in this category are also selected to assess students' understanding of the content present in the lesson/task sequence.
O – Other	Other reasons that PSETs select a task include, but are not limited to: - Behavioral Management - Task is "fun" - All kids should do this task – "I remember doing this task when I learned about density" - Discussion or Discourse opportunities - Science Talk opportunity

Coding Procedure:

- Read through task sequences created by PSETs.
- Use the codes above to capture the reasons PSETs give for selecting and using a task.
- The code "O" will only be used when:
  - None of the other four codes are apparent to the coders in the description of why a task is selected to be placed in the order that it has been set
  - There are so many other reasons given by PSET for choosing and sequencing the task as such that the reasons overwhelm the purpose of the task itself.
- Organize the reasons PSETs give for placing the tasks in sequence they provide.

- Determine if the instructional approach of the task sequences, based on reasons given by PSETs, is Reform or Traditional.
-
- Question 1c: When a traditional or reform approach was used, how did the capacity of the task sequence PSETs created compare to what PSETs say they wanted the task sequence to do?

		Reform	Traditional	
			Explain then Explore	Explain then Explain
Reform				
Traditional	Explain then			
	Explain then			

Figure 1. Comparing Capacity of Task Sequence to Intent of Task Sequence

Coding procedure:

- Use results from the coding of question 1a to determine how many PSETs selected/used tasks using a Reform, a Trad-N-R or Trad-N-N approach; record results.

- Use results from coding of question 1b to determine how many PSETs, based on their stated reasoning or intent, sequenced tasks to for the purpose of using a Reform, a Trad-N-R or a Trad-N-N approach; record results.
- Compare findings to determine trends in instructional approach of PSETs for the TSS.

3.6.1.2 Coding analysis for Research Question #2

In order to answer Research Question #2 – (What did the tasks that PSETs selected tell us about how they understood and addressed the prescribed LGs?) – I analyzed the data from the TSS Exam to respond to the three sub-questions related to the task sequences that PSETs created. The tasks PSETs selected for use in their task sequences were examined at face value to determine if the tasks they chose would address all four of the prescribed LGs from the assignment. A more detailed analysis followed, which included reading each task sequence in its entirety to examine PSETs' capabilities in discussing the value of the task in relation to the LGs. PSETs could have attended to the LGs addressed in their task sequences in several ways: stating the number of a particular LG met using a task, restating the LG in its entirety as evidence of the knowledge a task would address, or describing what students would be doing that connected to knowledge related to an unnamed LG. Finally, PSETs' alignment of selected tasks with prescribed LGs was compared with the capacity of the tasks for meeting those LGs. This information was compiled into a table to reveal PSETs' understanding of how the tasks met the prescribed LGs.

Question 2a: Did PSETs satisfy the LGs in the science lesson sequences they created (see Prescribed Learning Goals in Table 9).

Coding Procedure:

- Read through task sequences created by PSETs.
- Use the TSS Accurate Learning Goal/Activity Alignment Matrix (see Table 11) to determine if PSETs used tasks in their lesson sequences that collectively addressed the four prescribed Learning Goals.
- Determine which Learning Goals each PSET addressed or didn't address

- Compile results in Table 10.

Table 10. TSS Prescribed Learning Goals

Learning Goals
1. Objects can be characterized in terms of property of density. Density is a measure of the amount of matter contained in a given space.
2. We measure the amount of matter in terms of mass. And we measure the space an object takes up in terms of volume.
3. All uniform solid objects made of the same material will have the same density regardless of their particular volume, mass, shape, or color. Therefore, density is a property of material kinds, not just of particular objects.
4. Be able to calculate an object's density using the ratio of mass to volume (d = m/v)

Table 11. TSS Perceived Learning Goal/Activity Alignment Matrix

Learning Goal (LG)	1	2	3	4
Number of students addressing the LG				

Question 2b: From the PSETs' perspective, what Learning Goals did they address in the tasks they selected?

Table 12. Codes for PSETs' Identification and Description of Learning Goals

Code	Definition/Description
LG-N – Learning Goal Number	PSET clearly states the numbered Learning Goal(s) that the task addresses.
LG-R – Learning Goal Restated	PSET clearly restates the actual prescribed Learning Goal in their discussion of why they selected specific tasks.
LG-K – Learning Goal Knowledge	PSET clearly describes knowledge or understanding that students should acquire after participating in a selected task. This knowledge should be connected to one of the four prescribed Learning Goals.
O – Other	PSET describes other information that students should have access to in the lesson sequence that is not part of the prescribed Learning Goals. Or the PSET does not clearly align the task sequence to the LGs.

Coding Procedure:

- Read through task sequences created by PSETs.
- Use the codes above to determine if and how PSETs feel they are addressed the prescribed Learning Goals in the task sequence they created. See Table 9 and 11 when necessary.
- Compile the reasons each PSET gave for selecting tasks to organize these in a sequence.

Determine how well PSETs attended to the prescribed Learning Goals in their discussion of what students should know and understand after participating in their lesson sequence.

Question 2c: When selecting tasks to address Learning Goals, how did the Learning Goals that PSETs think they were addressing compare to the Learning Goal capacity of the tasks they were selecting?

Table 13. TSS Accurate Learning Goal/Activity Alignment Matrix

	Pink	Red	Orange	Yellow	Green	Blue	Purple	Brown	Black	Gray
LG1		X		X	X	X	X	X	X	

Table 13 continued

LG2	X		X	X			X			X
LG3		X		X				X	X	X
LG4		X	X	X	X				X	X

Coding Procedure:

- Read through task sequences created by PSETs.
- Use the TSS Accurate Learning Goal/Activity Alignment Matrix to determine if PSETs were able to adequately address each of the prescribed Learning Goals in their task sequence.
- Use the TSS Accurate Learning Goal/Activity Alignment Matrix to determine if PSETs were able to adequately match tasks to the prescribed Learning Goals that the task was capable of addressing.
- Use this information to articulate PSETs' abilities to make use of tasks for the purpose of meeting prescribed Learning Goals.
- Compile results in Table 11.

3.6.2 Data analysis

While my data consists of one primary source, I used distinct types of measures to analyze the data. Table 14 describes how each question was address and analyzed. The TSS Exam submissions were read and coded differently for each of the research questions.

Table 14. Data analysis structure used to address each research question

Research Question	Data	Analysis
1	TSS	• Lesson sequences will be examined and coded to reflect whether the placement of the tasks in the sequence aligned the sequence to reform-based approaches or traditional approaches to instruction • Lesson sequences will be carefully read and coded to determine what type of approach PSETs are using based on their statements in the task sequences • A matrix will be generated to compile information from both coding passes to illustrate where trends lie for reform and traditional instructional approaches
2	TSS	• Lesson sequences will be examined to determine if all four Learning Goals can be met in the sequence generated by PSETs • Lesson sequences will be carefully read in their entirety to determine

Table 14 continued

	which Learning Goals PSETs intend to address in each of the tasks they select • Results will be compiled into a matrix to examine if capacity of the tasks selected by PSETs match with the Learning Goals that are capable of being met in those tasks.

4.0 RESULTS

This chapter is organized into two main sections which coincide with the two research questions and their sub-questions. In section 4.1 I discuss the findings that contributed to my understanding of the instructional approaches PSETs used in the task sequences that they planned. I describe the two primary categories that emerged from the data analysis and provide examples from their task sequences to support my claims in these findings. Finally, I compare what the task sequences suggest about instructional approach and compare the explanations provided by PSETs. In section 4.2 I look at how PSETs address the prescribed Learning Goals (LGs) through the task sequences that they created in response to the TSS Exam. I examine their adeptness in attending to specific LGs as well as their ability to discuss the ways in which a task aligns to particular LGs. Finally, I examine their use of a task for the purpose of meeting a specific LG and the capacity of a task to meet one or more of the LGs.

4.1 PSETS' APPROACH TO PLANNING FOR TEACHING AN ELEMENTARY LESSON IN SCIENCE

As mentioned earlier, planning is a key component to teaching (So, 1997). In science education, the use of a reform approach to planning and instruction was encouraged because a reform approach provides the opportunity to explore phenomenon before an attempt is made at explaining it. Historically, however, a traditional approach to science planning and instruction has been used. Typically, a traditional approach to science instruction begins with the explanation of the topic, which may include definitions of vocabulary terms, mathematical equations related to the topic, and general descriptions of why or how phenomena came to exist. This explanation is followed by a controlled encounter with materials related to the phenomena so that explanatory information can be verified. In a traditional approach, the phenomena and the explanation are highlighted and reinforced through procedural instructions, and very little opportunity for variation exists. For example, a lesson on density might entail a comparison between two materials (e.g., steel versus plastic) and the formula by which density is computed (density = mass/volume). Upon completion of an Elementary Science Methods course, where a reform approach to instruction was taught and supported, it is reasonable to wonder what type of instructional approach PSETs will utilize when they needed to plan for impending science lessons. Additionally, it is interesting to explore the capacity of the tasks PSETs will select and the intent they have for these tasks to achieve their LGs.

4.1.1 Use of a reform or traditional approach in planning to teach science

Question #1: *What did the sequence of tasks that PSETs selecedt tell us about their approach to teaching science?*

The tasks given to PSETs in the TSS Exam packets were quite varied, and each had its own capabilities (See Appendix A for a complete copy of all ten tasks). (See Table 15) This table explains the instructional function of each task in the TSS exam. It is clear that not all tasks function in the same way(s) as other, more versatile tasks.

To simplify this information regarding task type, (i.e., Engage, Explore, Explain, Distractor) and to more narrowly define the primary function of the ten tasks provided to PSETs in the TSS Exam, the tasks were regrouped. The purpose of this regrouping was to highlight the foremost purpose of the tasks and streamline the principal features of the tasks so as to illustrate their primary instructional function. (See Table 16) In this table, the primary purpose of each TSS Exam task is re-categorized. This regrouping will be utilized in the analysis of the data evaluated for this study regarding Question 1 and its sub-questions.

Table 15. Task Function Alignment

Engage Tasks	Explore Tasks	Explain Tasks	Distractor Tasks
• Purple • Orange • Green • Pink	• Yellow • Gray • Blue • Purple • Brown	• Black • Red • Orange • Green • Pink • Yellow • Gray • Brown	• Blue • Purple • Brown

Table 16. Primary Purpose of TSS Exam Tasks

Primary Task Purpose	Solid State Engage/Explain	Solid State Explore/Explain	Solid State Explain	Liquid State Explore Explain
Tasks Best Suited for Purpose	• Green • Orange • Pink	• Yellow • Gray	• Red • Black	• Blue • Purple • Brown

4.1.1.1 What the task sequences tell us about the instructional approach of the task sequences

Question 1a: *What approach, traditional or reform, do PSETs take when creating a science lesson sequence?*

Recall that each PSET was to create a lesson sequence on the topic of density using the ten tasks that were provided in the TSS Exam packet. The students could use any or all of the tasks and organize these in a combination that they felt would support students in achieving the prescribed Learning Goals. Table 16 groups each of the original written tasks into four primary categories. The goal of sub-question 1a was to examine the task sequences, as they were organized by each of PSETs, and then draw a conclusion regarding the intent of the tasks in the sequence that they had been placed. Task sequences were then coded as: Reform – Explore-Explain approach, Traditional – Explain-Explore approach, or Traditional – Explain-Explain approach. In other words, a reform sequence emphasized the need for students to explore the phenomenon of density before trying to explain it for themselves, whereas a traditional approach to task sequencing explained density before exploring or explained without exploring at all!

When PSETs created their task sequences, most of them used a traditional approach. This meant that the tasks selected and sequenced by PSETs provided students with explanations about content on density before they provided students with the opportunity to explore density in various solid objects so that comparisons could be made. The majority of the participants (81%) created task sequences that appeared to incorporate a traditional approach to instruction that offered explanations before exploration. These were coded as Traditional – Explain-Explore (Trad – N-R). One of the sequences in the sample was coded as Traditional – Explain-Explain (Trad – N-N).

While most of PSETs created task sequences that were traditional, some created task sequences that were more in line with a reform approach for planning to teach science. Nineteen percent of PSETs created task sequences that appeared to use a reform approach to instruction. The reform approach would provide students with the opportunity to explore phenomena around the concept of density before explanations of what density is were provided.

4.1.1.2 What the PSETs tell us about the instructional approach of the task sequences

Question 1b: *When PSETs created science lesson sequences that reflected a traditional or a reform approach, what were the reasons they gave for the tasks they selected?*

Regardless of whether the task sequences that PSETs created used a traditional or reform approach, all participants responded to probing questions that offered reasons describing intent for both the selection and placement of each task. Each of the task sequences was read carefully to determine PSETs intent regarding selection and sequencing of the tasks. Some PSETs were brief in their responses to the probing questions, "Why did you select this task?" and "Why did you place this task here in the instructional sequence?" Other PSETs wrote paragraphs-long responses, carefully describing their thinking in the process of completing the assignment.

PSETs' responses to the probing questions were read carefully to better understand their intent in developing them. Responses were coded in the same way for sub-question 1b as they were for sub-question 1a. In other words, sequences were coded as supporting one of several approaches: a Reform Approach – Explore-Explain, a Traditional Approach – Explain-Explore, or a Traditional Approach – Explain-Explain.

PSETs' responses to the probing questions that explored the intent, or reasons for including the tasks they placed into the sequence, were read carefully. The majority of PSETs' (78%) task sequences were coded as having an intent that was Traditional – Explain-Explore, and only one participant (2%) was coded as being Traditional – Explain-Explain. One-fifth (20%) of PSETs in our sample group developed task sequences that were coded as having the intent to use a Reform approach.

Participants with sequences that were coded as having an intent that aligned to a Traditional – Explain-Explore approach, stated that students needed to have access to vocabulary terms and definitions for these terms (e.g., density, mass, volume). For example, PSETs stated that they wanted the students "to learn the basics of density before they move on. Students should know the definition of what they are learning before we actually do anything else with it," (PSET#28), and that the "students need to know the equation to find density in order to discover the density of objects which they will be doing during various (upcoming) activities" (PSET #52). Statements like these are their reasons for giving students Explanatory information initially, suggesting that students will not be capable of exploring density unless they know what density is and how to properly calculate it using a specific formula.

One PSET talked about her sequence in a way that described how she would explain density to her students using a couple of tasks, then she would go on to explain density further by using tasks to reinforce the idea of density. This task was coded as a Traditional Explain-Explain Task (Trad N-N). That PSET did not include any tasks in her sequence that provided students with opportunities to explore phenomenon related to density, and she did not suggest modifications to the selected tasks that could have supported work of this type during the sequence. She was the only participant from our sample group that created a task sequence in which this type of approach was described. (See Appendix B, Student #10).

Out of the participant group, twenty one percent of PSETs responded to the probing questions from the planned task sequences that they intended to allow students to explore ideas around density before they (or the students) would explain density. This means that this group of participants selected tasks that supported an Explore before Explain approach in their sequences. Sequences of this type were coded as Reform. Not only did these PSETs select tasks that provided opportunities to explore phenomenon, they also responded to the probing questions in ways that helped us to understand their intent to have the students explore concepts around density before providing definitions or formulas. For example, “I chose this (Pink) activity because it gives the students the opportunity to explore the concepts of mass and volume, central properties of objects that play a large part in the understanding of density, and collect their own first-hand data which may serve as a valuable representation.” (PSET #29). Another PSET said, “I would not tell the students that the reason behind the different layers of liquids is density. I would present this liquid-layers demonstration, and then have students discuss in their groups what they might think is causing the liquids to layer on top of one another. I would not explain why or how, as this is just the explore part of the Learning Cycle.” (PSET #54).

It is interesting to note that just over half of PSET participants (51%) in this study told us that they were thinking about the Learning Cycle as they worked to develop their task sequence for the TSS Exam. They would say things like, “I want to stick to the Learning Cycle” in their planned task sequence (PSET #10) and “the learning cycle allows students to explore the concept on their own before having it explained to them by the teacher” (PSET #18). While more than half of PSETs explicitly referred to the Learning Cycle at least once in their task sequences, and even to the importance of having students to explore concepts prior to having these ideas explained to them, just over three-fourths of them (79%) described instructional approaches that were traditional in design.

4.1.1.3 What the task sequences tell us about approach to instruction compared to what the PSETs have to say about it

Question 1c: *When traditional or reform approaches were used, how did the capacity of the task sequence PSETs created compare to what PSETs say they wanted the task sequence to do?*

Generally speaking, when PSETs created task sequences that had the capacity for supporting a Traditional approach to instruction, the intent they had for the tasks in the sequence also followed a Traditional approach. Likewise, when PSETs created task sequences that had the capacity for supporting a Reform approach to instruction, the intent they had for the tasks in the sequence also followed a Reform approach (see Figure 2). For only three percent of occurrences, the capacity of the task sequence was a Reform approach, but the intent of PSET was a Traditional approach. For only four percent of occurrences, the capacity of the task sequence was a Traditional approach, but the intent of the PSET was a Reform approach. Overall, the task sequences that the PSETs put together met both the capacity for the tasks and the intent from PSETs point of view. This is not to say that if a PSET intended to use a reform approach to planning that they were able to do this. Rather, the function of the tasks that they selected matched the intent that they had for those tasks – intended instructional approach aside.

Capacity of Tasks Selected/Used in Lesson Sequence

Stated Reason/Intent for Lesson Sequence		Reform Approach	Traditional Approach: Trad N-R	Traditional Approach: Trad N-N
Reform Approach		12	3	--
Traditional Approach	Trad N-R	2	54	--
	Trad N-N	--	--	1

Figure 2. Comparing Capacity of Selected Tasks with Intent for Selected Tasks

4.2 PSETS CAPACITY IN ATTENDING TO PRESCRIBED LEARNING GOALS THROUGH THE TASKS THEY SELECT

Selecting appropriate task for planned instruction is only half of the battle when preparing to teach. Tasks that are chosen for implementation must also align to specific LGs, which are often prescribed by the curriculum in use. Just as some tasks are more adept at supporting a particular approach to instruction, traditional or reform, some tasks are also more capable of meeting particular LGs.

The TSS Exam asked PSETs to design task sequences using ten tasks that were provided by the instructors. Additionally, they were asked to keep in mind that the task sequences were a means "through which (your) students can achieve the desired Learning Goals." (See Table 9.) In short, the tasks selected by the PSETs and placed into their sequences should address the LGs that were provided in the TSS Exam.

4.2.1 Task selection for the purpose of attending to learning goals

Question #2: *What did the tasks that PSETs selected tell us about how they understood and addresed the prescribed Learning Goals?*

As stated above, the tasks given to PSETs in the TSS Exam were quite varied regarding their instructional purposes. (See Table 15.) Task Function Alignment shows the function and capacity of each of the ten tasks, instructionally. Likewise, the capability of the ten tasks to meet one or more of the prescribed Learning Goals was also mixed. Table 17 breaks down which tasks are capable of meeting each of the LGs. It may be noticeable that some tasks are more versatile than others with regard to the prescribed LGs. In particular, the Yellow task is capable of meeting all four of the Learning Goals, while the Pink task is only capable of meeting Learning Goal #2.

Table 17. Accurate Task Learning Goal Alignment

Learning Goal (LG)	Tasks that Meet the LG		
#1 – definition of density **Objects can be characterized in terms of the property of density. Density is a measure of the amount of matter contained in a given space.**	Yellow Green Red	Black Brown Blue	Purple
#2 – definition of mass and volume **We measure the amount of matter in terms of mass. We measure the space an object takes up in terms of volume.**	Orange Pink Yellow	Gray Purple	
#3 – density is an intrinsic property of matter in a uniform solid state **All uniform solid objects made of the same material will have the same density regardless of their particular volume, mass, shape or color. Therefore, density is a property of material kinds, not just of particular objects**	Yellow Red Black Gray	Brown	
#4 – ratio for calculating density; d = m/v **Being able to calculate an object's density using the ratio of mass to volume (d = m/v)**	Green Orange Red	Yellow Black Gray	

4.2.1.1 What the task sequences tell us about their ability to satisfy the learning goals

Question 2a: *Did PSETs satisfy the Learning Goals in the science lesson sequences they created?*

PSETs were given the opportunity to develop a task sequence using any or all of the ten tasks that were provided in the TSS Exam packet. Generally speaking the task sequences created by the PSETs were capable of supporting all four of the prescribed LGs. More specifically, when the task sequences were examined by the coders, it was determined that almost all PSETs (97%) were able to meet all four of the Learning Goals in their task sequences. Two of the participants created task sequences which indicated that three of the four LGs be satisfied. (See Table 18)

Overall, PSETs were capable of generating task sequences that had the potential to address all four of the prescribed LGs.

Table 18. TSS Perceived Learning Goal/Activity Alignment Matrix

Learning Goal (LG)	**1**	**2**	**3**	**4**
Number of students addressing the LG	72	71	71	72

4.2.1.2 What the PSETs tell us about the tasks selected regarding the learning goals

Question 2b: *From PSETs' perspective, what Learning Goals did they address in the tasks they selected?*

As mentioned earlier in this chapter, when PSETs created their task sequences, they were asked to respond to two probing questions asking them "Why did you select this task?" and "Why did you place this task here in the instructional sequence?" As stated above, the responses to these questions varied in length. However, all written responses were read very carefully in order to understand the ways in which PSETs addressed the LGs and the knowledge related to these through the tasks that they chose for their task sequences.

Four codes were developed to assist in determining how PSETs addressed the LGs. (See Table 18) The codes LG-N, LG-R, and LG-K were used when LG knowledge was present in an explicit and/or implicit manner. The code O (Other) was used when knowledge connected to any of the four prescribed Learning Goals could not be identified with certainty. This table illustrates examples of responses from PSETs as to how the LGs were addressed in their responses to the probing questions from the TSS Exam.

Table 19. How PSETs Addressed the Learning Goals

Code	Definition/Description
LG-N – Learning Goal Number	PSET clearly states the numbered Learning Goal(s) that the task addresses.
LG-R – Learning Goal Restated	PSET clearly restates the actual prescribed Learning Goal in their discussion of why they selected specific tasks.
LG-K – Learning Goal Knowledge	PSET clearly describes knowledge or understanding that students should acquire after participating in a selected task. This knowledge should be connected to one of the four prescribed Learning Goals.
O – Other	PSET describes other information that students should have access to in the lesson sequence that is not part of the prescribed Learning Goals. Or the PSET does not clearly align the task sequence to the LGs.

In addition to the variety of ways in which PSETs addressed the LGs, they talked about some LGs more often than others in their task sequences. (See Table 19)

Table 20. Frequency with which Each of the Learning Goals is Addressed by PSETs

Learning Goal	LG 1	LG 2	LG 3	LG 4
Number of times the LG was addressed by PSETs	274	228	147	170

Table 19 provides a summary of the number of times that PSET participants referenced the LGs in any one of the three ways described in Table 18. Every time a PSET implicitly or explicitly addressed one of the four LGs in their responses to the probing questions for a task, it was coded and added to the count. To be clear, if a PSET restated a LG and then described knowledge that students could attain through the task, this would be coded as LG-R,K and this mention of the task addressing the LG was counted as one instance. If PSET went on to restate a second LG and again described knowledge that could be attained by the students via the task, this would again be coded as LG-R,K and another count for the same task would be added to the total. As such, tasks could get as many as four total counts if PSETs aligned a task to all four of the LGs. These counts, and their ability to match, not match, or have an unclear match to the four LGs will be discussed next in this chapter.

4.2.1.3 What the tasks tell us about their capacity to meet learning goals compared to what the PSETs have to say about it

Question 2c: *When selecting tasks to address the Learning Goals, how did the Learning Goals that PSETs think they were addressing compare to Learning Goal capacity of the tasks they were selecting?*

PSETs' responses to the probing questions in the TSS Exam were evaluated to determine which LGs they hoped to address through the tasks they selected for their task sequences. Their responses were compared with the capacity of the tasks to meet one or more of the four LGs. This was done to see if there was a match between what PSETs suggested the task could do to meet the LGs and what the capabilities of tasks actually were, regarding achievement of the LGs. The table contained in Figure 3 quantifies the ability of PSETs to match their selected tasks to the LGs with accuracy (see Table 17.) As it has been noted earlier in this chapter (see Table 20), PSETs attended to some Learning Goals more than they did to others.

PSETs' abilities to match tasks from their sequences to the LGs that the tasks had the capacity to meet, were mixed. Figure 3 illustrates a summary of the findings regarding PSETs' capabilities on this point. It should be noted that while PSETs addressed LG#1 more than any other LG in their task sequences, they were most accurate in aligning tasks to LG#4, which dealt with calculating the ratio for density; d=m/v – 95% accuracy. LG#2, which addressed the definition and application of mass and volume, was the LG that they most often struggled to match correctly to the tasks that they selected for their task sequences; PSETs misaligned LG#2 35% of the time.

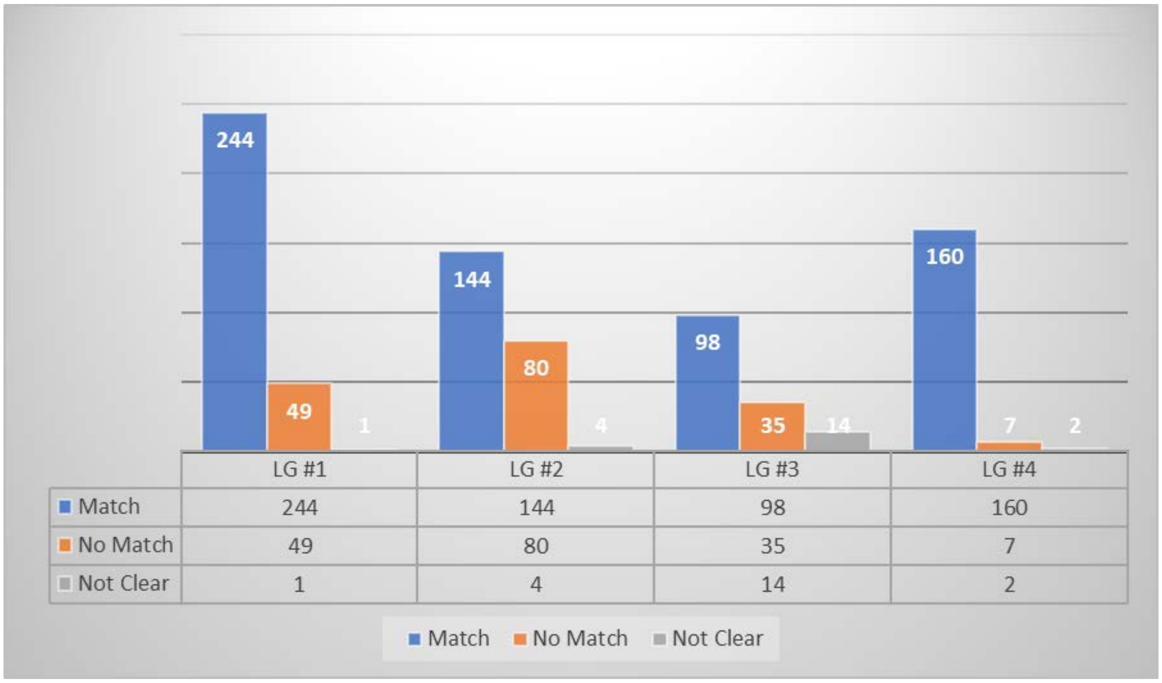

Figure 3. Summary of Accurate Learning Goal Alignment by PSETs on the TSS Exam

LG#3, which dealt with density as an intrinsic property of matter – regardless of mass, volume, color and shape, had the second highest mismatch at almost 24%. PSETs were unclear in their alignment to LG#3 more often than the other three LGs. This means that when the data was coded for how PSETs addressed the Learning Goals. (see Table 19) These participants either did not align any of the tasks in their task sequences to LG#3, or all of their attempts to match a task to this LG were incorrect. For those instances, the code "not clear" was used to describe how PSETs understood the capacity of the task(s) to meet the LG. Overall, PSETs were unclear in the matching of LG#3 to the tasks that they selected for 10% of the time.

Recall the task groupings from Table 16. These same groupings were used to analyze PSETs capabilities in aligning particular types of tasks to the LGs and the capacities of the selected tasks to meet the LGs identified by PSETs. Also recall that a task could have had as many as four counts if PSETs attempted to align a task to all four of the prescribed LGs. The summary of Accurate Task to Learning Goal Alignment by PSETs (see Figure 4) organizes the data from this part of sub-question 2c. By organizing the data in line with the purpose of the tasks, we can better see which types of tasks PSETs have difficulty aligning to LGs.

Upon initial glance, you may notice that tasks categorized as SS-R/N or Solid State-Explore/Explain, had the highest alignment of tasks to LGs. This might be due to the fact that one of the tasks in this category met all four of the LGs. PSETs often stated, “This task (Yellow) meets all of the stated Learning Goals.” When PSETs made a statement like this, their response to the probing questions for the task was coded as LG-N for each of the four LGs, so that it received four counts. This also meant that when PSETs made statements like this they were correctly aligning a task to all four of the LGs. This decreased the likelihood that there would be “no match” or a “not clear” match for tasks in this category.

Figure 4. Summary of Accurate Task to Learning Goal Alignment by PSETs

Table 21. Accurate Alignment of Task Groupings to Prescribed Learning Goals

	Solid State Engage/Explain	Solid State Explore/Explain	Solid State Explain	Liquid State Explore/Explain
Match	166 – 63%	223 – 90%	144 – 81%	107 – 60%
No Match	90 – 34%	17 – 7%	32 – 18%	32 – 18%
Not Clear	7 – 3%	7 – 3%	2 – 1%	40 – 22%

Tasks in the SS-G/N or Solid State-Engage/Explain did not fare as well. PSETs misaligned tasks in this category to LGs just over one-third of the time (34%). This was the highest percentage of misaligned tasks where the LGs were concerned. Interestingly enough, two of the tasks in this grouping (Orange and Pink) aligned to LG#2. Figure 4.2 shows that this LG – which was aligned to defining mass and volume – was a challenge to PSETs when they attempted to accurately match LGs to it.

Tasks in the LS-G/N or Liquid State-Engage/Explain had very mixed results. While PSETs were able to match tasks in this group accurately to the LGs 60% of the time, they were "not clear" about how the tasks aligned to the Learning Goals 22% of the time, an amount far exceeding any other task grouping for the category "not clear". While PSETs clearly used the Liquid State tasks in their task sequences, they were often focused on discussing the "liquid" aspect of the tasks. These tasks were only vaguely aligned to Learning Goals #1, #2 and #3, and there was no alignment to Learning Goal #4. Recall that the content-grounded Learning Goal (#3) for the TSS Exam discussed that density is an intrinsic property of matter: that uniform ***solid*** materials have the same density regardless of the volume, mass, shape or color. Since the PSETs selected tasks that used liquids to compare density, they could not meet this LG with fidelity. Again, it is interesting to note from the bar graph in Figure 4.2, that LG#3 was the LG that had the highest percentage of "not clear" alignment by PSET participants.

In general, the findings in this chapter indicated two important things: PSETs typically created task sequences that utilized a traditional explain-then-explore approach to teaching science, and PSETs appeared to be more capable of accurately aligning tasks to fact-based LGs, though they did also find success with the content-grounded LG. All of the data in this chapter came from one source, the TSS Exam, yet from this single source we can see where some of the most basic, yet important challenges lie for PSETs. Planning to teach science in a way that supports reform initiatives requires that teachers understand, not only science content knowledge, but also the pedagogy that supports the construction of this knowledge (Schulman, 1986). The majority of PSETs in this study used a traditional approach to teaching science. They appeared to focus on the fact-based information from the onset of the task sequence and then later in the sequence, they moved to tasks that supported elementary students in thinking about the content-grounded knowledge.

With regard to PSETs' understanding of the LGs and their ability to select tasks that are capable of meeting the LGs, the findings are related. Tasks that frequently supported fact-based Learning Goals, such as the Red and Black tasks (the SS-E grouping, Table 21), were often accurately aligned to tasks that had the capacity to meet those goals. Additionally, the data shows that when PSETs selected tasks that made use of authentic science practices to support content-grounded LGs (LG #3), they were successful. This suggests that PSETs are able to recognize that tasks in the SS-R/N grouping offer experiences that are related to more than just the facts. This finding is encouraging; more could be learned from further analysis of PSETs responses to the probing questions for Yellow and Gray task selection. Finally, the liquid tasks (LS-R/N) were the most problematic for the PSETs, yet they persisted in using them; 22% of the PSETs had no clear match to any of the LGs when these tasks were used.

5.0 DISCUSSION AND CONCLUSIONS

One goal of the science methods course situated in this particular preservice elementary teacher program was to support novice elementary teachers in planning science lessons that would utilize a reform approach to instruction (Forbes, 2011; Mikeska Anderson & Schwartz, 2009; Ross & Cartier, 2015). Another goal of this course was to provide these same PSETs with experiences to help them scrutinize instructional tasks so that they can determine whether or not particular activities align with prescribed fact-based and/or content-grounded Learning Goals (Mikeska, Anderson & Schwartz; 2009; Ross & Cartier, 2015; Schwartz et. al, 2008). The motivation for a focus on reform-oriented planning and the capabilities of PSETs to select tasks and accurately align them to predetermined Learning Goals (LGs) is three-fold. First, understanding science as a discipline is essential. It is necessary to have a grasp of the nature of science, as well as the types of practices that support scientific ventures. Instructors are often the force behind redirecting PSETs' ideas about what it means to do science in an elementary classroom (Davis, Pettish & Smithey, 2006). Second, PSETs are often concerned that they lack robust science content knowledge. A grasp of content knowledge, in addition to having insight regarding how this knowledge comes to fruition, can provide PSETs with a framework for planning to teach science through authentic science practices (Mikeska, Anderson & Schwartz, 2009). Finally, fact-based and content-grounded LGs need to be adequately and accurately addressed when planning to teach science. Instructors need to support PSETs in choosing instructional tasks in a selective way to ensure that both types of LGs are present in lesson plans (Ding & Carlson, 2013; Schwartz, et. al, 2008). To explore PSETs' development in their planned instructional approaches and capabilities regarding task-to-Learning Goal alignment, the course instructors developed the Task Selection and Sequence (TSS) Exam. This culminating assignment, given at the very end of the elementary science methods course, served as the data source for this research project.

There were two primary goals for this exploratory research study: to better understand the type of instructional approach PSETs utilized through their selection of provided tasks and their descriptions of their intent for these tasks during enactment, and to determine if PSETs were capable of aligning instructional tasks to prescribed LGs in light of the instructional capacity of the selected tasks. At the conclusion of their time in an elementary science methods course, task sequences created by PSETs were examined in light of the two overarching research questions in order to better understand their inclinations regarding their science planning practices. In working to respond to the research questions and sub-questions it became abundantly clear that PSETs are capable of meeting the course goals; however, they do so with varying success.

The first set of findings presented in Chapter 4 concluded that, while all 72 PSETs in this study successfully crafted lesson sequences utilizing the ten tasks that had been provided, they most often used a traditional approach while planning. The PSET participants in this study had been exposed to two complete Learning Cycles during their coursework and had enacted a complete Learning Cycle lesson in their elementary placement classrooms. When given the opportunity to develop a task sequence on the topic of density using any or all of the ten tasks provided by the science instructors, PSETs chose to create lesson sequences that provided explanations of concepts about density prior to offering students time for exploration of the phenomenon related to this topic (Davis, Pettish & Smithey, 2006; Mikeska, Anderson & Schwartz, 2009).

The second set of findings concluded that, although nearly all PSETs in this study crafted lesson sequences with the potential to meet prescribed LGs, not all participants accurately aligned tasks they selected with these LGs. It should be noted that none of the task sequences were identical (Ding & Carlson, 2013). Findings indicated that PSETs were capable of accurately aligning the various types of tasks that they selected for their lesson sequences to the prescribed LGs (Mikeska, Anderson & Schwartz, 2009, Schwartz, et. al, 2008). It seems, however, that they were better at aligning some types of tasks to LGs than other types. (Schwartz, et. al, 2008).

5.1 EXAMINING THE FINDINGS

In order to respond to my first research question, I examined the instructional approach of the task sequences created by PSETs and compared these to the intent toward the instructional approach that PSETs described. In general, I found that the task sequences PSETs created supported the instructional approach that they intended to use, whether that was a traditional or a reform approach. This means that they were able think about how they wanted to plan to teach elementary students about density and then select the tasks that would support the approach of their choice.

The majority of PSETs developed task sequences that supported a traditional approach to instruction. In their responses to the probing questions, they described that they intended to provide elementary students with fact-based explanatory knowledge and information before they offered the students with a chance to explore the phenomenon and participate in tasks that made use of authentic science practices. When PSETs did develop a task sequence that supported a reform approach to instruction, the tasks they selected offered elementary students the opportunity to explore concepts through activities such as data collection and comparisons across samples. Tasks that supported fact-based or explanatory knowledge came after tasks that supported explorations.

Some PSETs did not have intended approaches to instruction that matched their task sequences. A small group of PSETs developed task sequences that supported a traditional explain-then-explore approach to instruction but then went on to describe their intentions for the task sequence to function as an explore-then-explain sequence. They provided opportunities for exploration first by omitting the fact-based information from the tasks - revisiting this and other explanatory information later. Another small group of PSETs did just the opposite. They developed task sequences that had the potential to make use of exploratory tasks first and explanations later. When these PSETs described their reasons for selecting the tasks, however, they focused on the fact-based information that early tasks contained. Once this information was adequately revealed, they planned to give the elementary students opportunities for exploration.

While most PSETs appeared to value instructional opportunities that placed fact-based information up front in lesson sequences, some seemed to realize that exploring phenomenon related to the topic early on was more useful for students. The TSS Exam didn't support one type of approach over the other. Rather, the goal was to explore what PSETs might do when given the opportunity to craft a lesson sequence without any guidance from an instructor or an instructional framework that clearly supported a particular type of approach. The results indicated that taking up a reform approach to instruction, without guided support was challenging for PSETs (Davis, Pettish & Smithey, 2006; Ding & Carlson, 2013; Forbes, 2011; Schwartz, 2008).

Selecting tasks that accurately align to LGs is challenging for in-service elementary teachers let alone PSETs. Task selection can be a personal choice and often PSETs choose to make use of tasks that are predictable or “fun” even though they don’t clearly align to the prescribed LGs (Appleton & Kindt, 2002; Davis, Pettish & Smithey, 2006; Mikeska, Anderson, & Schwartz, 2009). Additionally, the capacity of a task to meet a LG can be unclear to PSETs. Research indicates that task-to-Learning Goal alignment should be a component piece of methods courses in teacher education (Forbes, 2011; Ross & Cartier, 2015). When LGs are not properly aligned to tasks, they may not be met during instruction at all.

The large majority of PSET participants in this study were able to identify tasks and place them in a sequence so that all four of the prescribed LGs could be addressed. Additionally, PSETs aligned the tasks they selected for their sequences to fact-based LGs most often. The content-grounded LG (#3) was addressed the least often in comparison with the others. This finding may indicate that it was easier for PSETs to think about teaching tasks that contained factual information than those that contained content-grounded information (Davis, Pettish & Smithey, 2006).

PSETs aligned the tasks they selected to the prescribed LGs with mixed accuracy. Again, the fact-based LGs were accurately aligned to selected tasks most often. While the content-grounded LG didn’t land at the bottom of the pile (Learning Goal #2 did, but just barely), PSETs were only moderately accurate at aligning this LG to the tasks they selected. Additionally, the findings concluded that if PSETs were going to omit a LG entirely from their task sequence, it would be the content-grounded LG.

As was stated before, teaching science involves more than just attending to the facts. In addressing primarily fact-based information, it is worth wondering, “Where is the science?” This is because tasks that supported the content-grounded LG provided students with opportunities to engage with authentic science practices while the other types of tasks may not (Grossman, 2009; Ross & Cartier, 2015). The findings from this study not only indicated that PSETs addressed content-grounded LGs the least often, they showed that if PSETs are going to omit a Learning Goal from their task sequences, most often it will be the content-grounded LG. This finding is troubling because, as subject generalists, PSETs may not have a robust understanding of what it means to do science (Goldston et al., 2010; Mikeska, Anderson & Schwartz, 2009). Teacher educators need to continue to support PSETs in elementary science methods courses so that they understand the types of tasks that need to be present in science classes.

There were four different types of tasks that PSETs could select from in response to the TSS Exam. Upon reviewing the results exploring the abilities of PSETs to accurately align tasks to LGs, I was surprised by the findings. PSETs accurately aligned tasks that contained both fact-based and content-based LGs to their LGs most often. Tasks that only addressed explanatory knowledge were more challenging for PSETs to accurately align, and they struggled to determine which LGs the tasks would meet. These findings could be a result of the groupings of the tasks. The findings could also be indicative of what PSETs noticed about the tasks and then saw present in the LGs.

The group of tasks that contained liquid tasks faired quite poorly in regard to accurate LG alignment. This grouping had the lowest percentage of accurate alignment, and frequently PSETs wouldn’t align these tasks to any of the LGs. While the tasks in this grouping didn’t clearly align to any of the LGs to begin with, PSETs still chose to use these tasks rather frequently; however, they had trouble determining their purpose in the task sequences that they developed.

5.2 LIMITATIONS

This assignment was given to PSETs enrolled in a one-year MAT teacher preparation program where the participants were placed full-time in an elementary classroom during the day and attended master's courses four nights a week. The schools in which PSETs were placed offered various experiences regarding the opportunity to observe science instruction in the elementary classroom. While some PSETs had science a few times a week in their classroom placements, other PSETs never taught or even saw science being taught by their mentor teacher because they were placed in schools where science was considered a special, like music or art (and taught by a specialist). Those PSETs did not even have the potential to engage with science curriculum materials, let alone science instruction. These differing experiences could certainly contribute to the decisions PSETs made around their instructional approaches. Furthermore, their mixed experience in scrutinizing tasks to ensure that they align to lesson LGs, could have hindered their ability to do so clearly and accurately.

In working to develop codes for this research, data from other, smaller, sample groups of PSETs that could not be included in this study were coded for the same research questions. The findings from these other groups, while similar, were not a clear match. For example, the instructional approach Trad – N-N was developed because a handful of the PSETs in our sample groups used this approach. The finding from this study resulted in only one student from the entire sample using an approach like this. While the sample size for this group is adequate at 72, it is reasonable to say that different semesters generated different responses and results for the TSS Exam. Additional data would need to be collected from a similar group of PSETs to determine if there were larger implications for codes that were more prevalent in the sample data and nearly absent from the data set. Therefore the TSS Exam may be a good match for a Masters-level teacher preparatory program where PSETs are in placement at the same time that they attend methods courses.

The TSS Exam may not be a helpful measure of what PSETs are likely to do regarding choice of instructional approach and task-to-Learning Goal alignment if PSETs are not placed in an elementary classroom at the time of the methods course and consequent exam. Many undergraduate education programs situate full-time student-teaching in the final semester of coursework. Methods courses are therefore taught in the years before the student-teaching placement, and there may not be any prescribed order for when these courses are taken. It is reasonable to expect that the findings of this study would look quite different if the TSS Exam was given to undergraduate education majors that had minimal student-teaching experiences.

Many states are offering teacher certification through hybrid and exclusive online courses, including cyber student-teaching. It would be interesting to see how PSETs that had hybrid and cyber-only experiences both in preparation for teaching and during student-teaching might perform on an assignment like the TSS Exam.

5.3 IMPLICATIONS FOR PRACTICE

The TSS Exam offers teacher educators a glimpse of what PSETs take away from an elementary science methods course and makes practical use of when planning to teach science. This information is valuable and can be utilized in many ways in higher education. The TSS Exam was designed to help teacher educators consider which aspects of the methods course seemed to have staying power when the instructor was removed from the picture. Two areas of focus for this research study were PSETs' approach to teaching science and their understanding of the capacity for instructional tasks to meet prescribed LGs.

Most PSETs in this study planned and described task sequences that supported a traditional approach to instruction. Interestingly, over half of them indicated in their responses to the probing and reflection questions that they intended to make use of the Learning Cycle in the lesson sequence that they developed in the TSS Exam. This could be because they wanted to use terminology that matched the language they heard for fifteen weeks in the classroom, but there could be more to it. Research in teacher education indicates that while PSETs are often more than willing to take up reform approaches to instruction, and include tasks that provide students with opportunities to interact with authentic science practices, when the rubber hits the road, they stall (Appleton & Kindt, 2002; Mikeska, Anderson & Schwartz, 2009). Studies show that they will chose tasks that are familiar and predictable over those that are better aligned to what it means to do science (Davis, Pettish & Smithey, 2006). Likewise, their understanding of the content often drives the instructional decisions that they make around planning (Goldston et al., 2010).

PSETs in this research study selected an instructional approach and for the most part they stuck with it. Although I had hoped that more PSETs would use a reform approach when planning to teach, this finding is informative. For example, it has prompted me to wonder if giving a task like the TSS Exam earlier in the semester might provide a useful benchmark as the term progresses rather than as it comes to a close. Understanding how PSETs think about science instruction in an elementary classroom early in the methods course, rather than simply making presumptions, may help to direct the tasks and assignments given in the course as well as their field placements. TSS experiences could be unpacked openly during class time, having PSETs evaluate curriculum materials from their elementary classrooms so that they can consider the differences between traditional and reform approaches to instruction. Forbes (2013) recommends that PSETs work with authentic science curriculum materials so that they understand what it means to plan science lessons that represent science and its constituent practices. The TSS Exam supports work in this area, but its placement may be better suited elsewhere.

Elementary science tasks are easy to find. Aligning them to LGs is not easy to do. Work of this type is demanding for both the teacher educator and PSET. We know that teachers often modify the tasks that they teach in their classrooms regardless of the subject. We also know that modification of a task can change its purpose and therefore its capacity to meet a particular LG (Ball & Cohen, 1996; Brown, 2009; Davis & Krajcik, 2005). That said, supporting PSETs in scrutinizing tasks that they intend to use for the purpose of meeting prescribed LGs is an authentic instructional practice and, as such, it should be a prominent part of any teacher education program (Forbes, 2011; Grossman et al., 2009).

5.4 IMPLICATIONS FOR FUTURE RESEARCH

The structure of the TSS Exam has a great deal of practicality for both PSETs and teacher educators. An assignment like the TSS Exam gives PSETs the freedom to plan in a way that feels comfortable and reasonable to them. This could mean that they will choose to use methods from the course and carry out the intentions of those methods, but it is likely that they may not. As such, teacher educators have the opportunity to consider what PSETs have realistically taken away from courses like the elementary science methods course. Additionally, teacher educators can restructure and revisit tasks and assignments to determine what types of improvements should be made to methods courses. Thinking in this way can serve teacher educators in many disciplinary subjects. For example, if elementary math educators want to support the use of productive discussions in PSETs' math lessons, they could provide PSETs with sample solutions of an identical math problem from various elementary students. PSETs could then select which solutions they would want to have shared publicly with the class so as to support different types of mathematical knowledge around solving the same problem. The discussions that PSETs create could be coded in ways similar to the TSS Exam and these findings could help to inform future directions of elementary math education courses.

Another limiting factor around this study is that the TSS Exam is a stand-alone data source. There are no interviews, follow-up science lessons from PSETs while they were in the MAT program, or information about how they might have approached science instruction in the elementary classroom once they secured a job. While the TSS contains a lot of information, the information is static; therefore, developing research questions using a bottom-up approach was challenging. Additional data sources could have helped to make this study richer. That said, there is more information in the data that could be explored through different questions. A post hoc analysis of the ways in which PSETs identified the LGs could provide further insight into their thinking about what it means to align tasks to prescribed LGs. This would be another layer of information that could be used in preparation for teaching elementary science methods courses.

5.5 CONCLUSIONS AND CONTRIBUTIONS

When I arrived at Pitt 10 years ago my advisor at the time, Dr. Jennifer Cartier, ask me, “So why do you want to enter this program?” I told her very clearly, “I want to help teachers teach science better…”

So what does that mean, “Help teachers teach science better.” And can it be done?

I have learned lots of things during my time at Pitt. I have read more books than I ever thought I would and I have lost count of the number of journal articles that I have scoured and highlighted to grab a nugget of knowledge that might be used to “help teachers teach science better.” What I have learned is that helping teachers at the elementary and secondary levels to teach science is hard – I mean it is really hard. To that end, I feel that there are three things that challenge this process by inhibiting sound planning in the elementary science classroom: understanding the nature of science, understanding science content, understanding how to scrutinize tasks to ensure Learning Goal alignment.

Science is often seen by PSETs as this static collection of known factoids and so those individuals that are adept at science know lots of factual pieces of information (e.g., the earth is tilted at 23½^{o}, a first-quarter moon rises around noon and sets around midnight, there are three primary types of rocks; sedimentary, metamorphic, and igneous). While this might be true – that they know lots of “stuff,” they know more than the mere facts. Those that are adept at science understand science; they understand this patient process that oftentimes cannot be rushed or hurried along no matter how desperately we want it to happen faster. Additionally, they know how to ask questions that stem from what they notice about the world around them. They observe quietly and consider how encounters with phenomenon inform their thinking and their understanding.

Science can be challenging to master if we are simply going after the facts. In my experience, PSETs come to the science methods course wanting to teach this subject primarily because they know that their students will find it “fun.” While I understand the attraction to student engagement, I hope to share an appreciation for the process that is science. Educative Curriculum Materials support PSETs in understanding science and the processes that it contains. Engaging with ECMs can help PSETs to better understand science content (Davis & Krajcik, 2005). While facts are a part of understanding science, engaging with science allows teachers to think about how knowledge is constructed in this discipline. Understanding that the content ideas are grounded by science requires more than knowing the facts.

Recall that the tasks in the Liquid State grouping, while popular, posed significant problems for PSETs when it came time to align them to the prescribed LGs. They didn’t clearly match any of the four LGs. It is not a shock however, that PSETs persisted in using this group of tasks though they may have been difficult to align. This begs the questions, “Why use them?” Why try to fit the square peg into the round hole?” Findings to this research study support much of what is already well-documented. PSETs want to teach using a reform approach, but they cling to the traditional style; it is easier to align LGs to tasks that support fact-based information than tasks that support content-grounded knowledge. Not only do PSETs select tasks that address fact-based LGs most often, they also accurately align tasks to those fact-based LGs most often. If teachers don’t know the content in a subject like science, they are going to teach to the fun and the facts. Helping teachers teach science better is hard.

Teacher educators have their work cut out for them; there is still much to be done. The time that elementary teachers have to teach science is limited. Therefore, science tasks need to get the job done effectively. Scrutinizing tasks to ensure their fidelity and capacity regarding the lesson LGs is a necessary part of planning to teach. Teacher educators have a responsibility to support PSETs in determining the value of a task through engagement with curriculum materials. Work of this type can help to ensure that instructional time is not wasted and that tasks selected for instruction are effective for the intended audience.

This study contributes to the knowledge base by adding to what we know about how PSETs' approach to teaching science and their abilities in aligning tasks to LGs with fidelity and accuracy. Acquiring additional information about this group can help teacher educators to develop course goals and instructional tasks that can further support PSETs as they plan for teaching science in the elementary classroom.

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