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Curriculum Decisions and Reasoning of Middle School Teachers

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ABSTRACT

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For decades curriculum materials have been used as a means to reform the manner in which mathematics is taught. In an attempt to better understand what impact curriculum materials have on the teaching and learning of mathematics, researchers have begun to analyze the process in which teachers transform curriculum materials into instruction. Given that many of these studies have been broad in nature, I sought to study the specific decisions that three teachers made when planning lesson on geometric transformation and their reasoning for those decisions. In this study I found that while the participants in this study ignored the curriculum material I gave them as well as their district adopted materials in planning instruction, they made a wide variety of decisions with regards to other curriculum. In an attempt to describe this variety of decisions I expanded the previous methods of describing curriculum use decisions adding a *self-create* category as well as differentiating between the different types of adaptations teachers make. I also found that although teachers used different curriculum materials, they made similar decisions in how they planned the mathematics content of geometric transformations that seem problematic.

Keywords: curricular reasoning, curriculum, decisions, orientations, goals, resources, geometric transformations

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CHAPTER 1: RATIONALE

The teaching and learning of mathematics are inherently connected. Students learn mathematics by having experiences with mathematics (Von Glasersfeld, 1983) that originate from different activities (e.g., tasks, lectures, assignments) provided by mathematics teachers. Thus, teachers influence students' mathematical learning by providing different opportunities to learn. In reflecting on mathematics instruction, most people would agree that certain teaching practices seem more effective than others. Almost everyone can remember teachers who taught in a manner where concepts made sense and procedures seemed doable. Likewise, most people can relate to having a teacher who taught in a manner where learning was difficult. Researchers also have found that certain teachers consistently teach in a manner that supports student learning more than other teachers even when both classes have similar demographics (Hiebert & Grouws, 2007; Nye, Konstantopoulos, & Hedges, 2004).

It seems obvious that good teaching leads to increased student learning, but how does one influence student learning? What exactly does good teaching entail? Research indicates that there are many possible teaching factors that can influence student learning (Corey, Peterson, Lewis, & Bukarau, 2010; Hiebert & Grouws, 2007; NCTM, 2000, 2014). For instance the National Council of Teachers of Mathematics (2014) claims that teachers should incorporate the following practices in their teaching:

1. Establish mathematics goals to focus learning.
2. Implement tasks that promote reasoning and problem solving.
3. Use and connect mathematical representations.

4. Facilitate meaningful mathematical discourse.
5. Pose purposeful questions.
6. Build procedural fluency from conceptual understanding.
7. Support productive struggle in learning mathematics.
8. Elicit and use evidence of student thinking.

Researchers claim that by incorporating these kinds of practices students will better understand the concepts they are being taught rather than just be able to perform procedures (National Research Council, 2001; NCTM, 2000, 2014). Over the last several decades there has been a movement in the mathematics education field to incorporate these types of teaching practices in a variety of ways (National Research Council, 2001; NCTM, 2014; Stein, Remillard, & Smith, 2007).

One approach that mathematics educators and researchers have used to incorporate these teaching practices is through the development and use of curriculum materials (Ball & Cohen, 1996; Brown, 2002; Stein et al., 2007; Tarr, Chavez, Reys, & Reys, 2006). For this study, I define curriculum as any materials used by teachers to plan and enact instruction; therefore, this includes textbooks, online worksheets and activities, or lesson plans developed by a teacher. Several researchers note that curricula serve as a primary guide for teachers in deciding what topics to teach and how to present the content to students (Ball & Feiman-Nemser, 1988; Tarr et al., 2006). A logical assumption is that if teachers use curriculum materials that promote teaching practices shown to improve student learning, then their instruction will promote student learning. Figure 1 represents a model of curriculum, teaching, and student learning.

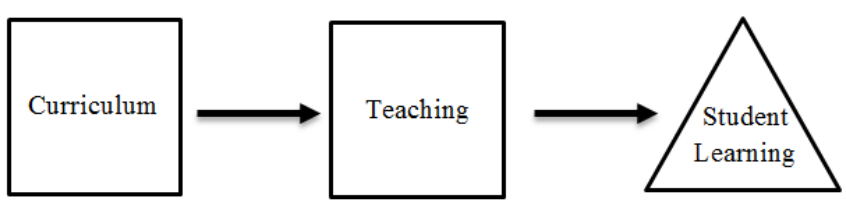

Figure 1. Relationship between teaching, curriculum, and learning.

Given the potential of curriculum to influence student learning, the relationship between curriculum, teaching, and student learning has been a large area of mathematics education research for the last two decades (Stein et al., 2007). A common finding of this research is that teachers do not necessarily implement curriculum in a manner that aligns with the teaching practices intended by the curriculum designers (Lambdin & Preston, 1995; Manouchehri & Goodman, 1998; Remillard & Bryans, 2004). Researchers claim that the extent to which teachers use curriculum varies and often classify teachers by the type of curriculum users:

1. Followers, or those who follow curriculum or use curriculum as their main guide in planning instruction.
2. Adapters, or those who adapt curriculum or use the curriculum, but change them to suit their needs.
3. Omitters or those who omit or skip parts of their curriculum or avoid using their curriculum entirely (Lambdin & Preston, 1995; Remillard & Bryans, 2004; Stein et al., 2007).

This indicates that the relationship between curriculum and teaching is more complex than previously thought and if we are to better understand this relationship then teachers' reasoning for their decisions they make with curriculum must be examined.

Recently researchers investigated why and how differences in curriculum use occur. Factors shown to affect curriculum use are: knowledge, beliefs, orientations, goals, identities, and external factors such as administrative support (Behm & Lloyd, 2009; Lloyd, Remillard, & Herbel-Eisenmann, 2009; Stein et al., 2007). Figure 2 displays the process by which teachers transform curriculum for instruction (Stein et al., 2007).

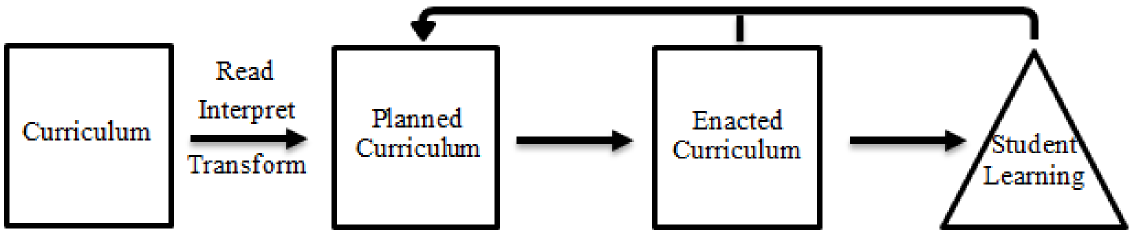

Figure 2. Process depicting how curriculum materials influence student learning**.**Adapted from *Second Handbook of Research on Mathematics Teaching and Learning* (p. 322), by Stein et al., 2007.

Curricula are read, interpreted, and transformed by teachers to create the planned curriculum or the lesson they will teach. Next, as teachers implement their lesson plan, they make derivations in response to unanticipated factors (e.g., students' responses, unforeseen problems) that affect the content that is taught. The enacted curriculum is what students are exposed to, which affects what they have the opportunity to learn. As depicted in Figure 2, both the enacted curriculum and student learning should affect how teachers plan for subsequent lessons or for the next time the lesson is taught.

While much knowledge has been gained about how teachers use curriculum materials generally, one area of research that still needs to be explored is teachers' decisions during the planning stage as to *what* curriculum aspects they use and do not use and *why* they make these decisions. As mentioned previously, researchers generally categorize teachers by the extent in which they use curriculum to guide their instruction and are often classified into groups such as followers, adapters, or omitters (Lambdin & Preston, 1995; Manouchehri & Goodman, 1998; Remillard & Bryans, 2004). This view of curriculum users is insufficient for two reasons. First, specific teachers have been documented as taking on multiple roles of follower, adapter, and omitter (Brown, 2002). Second, by categorizing teachers as one type of user does not account for the different ways in which they can adapt or omit curriculum materials, nor how it may affect student learning.

Teachers' decisions regarding what to use from curricula is especially important as these materials are transformed into planned curriculum. Sherin and Drake (2009) claim that teachers begin to make decisions regarding how to use curriculum as soon as they begin reading them. Researchers also claim that the ways in which teachers plan greatly affect how instruction is enacted (Clark & Lampert, 1986; Sherin & Drake, 2009; Stein et al., 2007), which influences students' opportunity to learn mathematics.

For my thesis I will add to the body of knowledge on teacher curriculum use by focusing on teachers' decision-making and reasoning during the planning stage. Specifically, I will seek to answer the following research question and sub-questions:

As teachers use curriculum to plan instruction what decisions do they make and what is their reasoning for these decisions?

1. What decisions do teachers make to follow, adapt, or omit curriculum as they plan?
2. What reasoning (i.e., orientations, goals, and resources) is influencing teachers' decisions to follow, adapt, or omit curriculum.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

In this chapter I discuss the literature relevant to answering my research questions. Specifically, I discuss research on curriculum use, curriculum decisions, and curricular reasoning. The second part of this chapter focuses on the framework I used to frame my study and answer my research questions. The third part of this chapter focuses on geometric transformation, the mathematics content area used for this study.

Curriculum Use

Researchers generally describe teachers' curriculum use in terms of the extent to which they use curriculum as a guide to plan and enact instruction. Brown (2002) described curriculum use in terms of *offloading, adapting,* and *improvising*. *Offloading* implies that teachers put responsibility for making instructional decisions on the curriculum by strictly following the activities and sequencing of the materials. *Adapting* refers to using a combination of curricula and personal resources to plan instruction. *Improvisation* refers to a teacher relying on curriculum in planning instruction. Lambdin and Preston (1995) described teachers' curriculum use in terms of being a *standards bearer*, a *teacher on the grow*, or a *frustrated methodologist*. The authors described a *standards bearer* as teachers who use a specific curriculum in planning and were successful in implementing this specific type of curriculum. A *teacher on the grow* is one who uses a specific curriculum to guide instruction, but is not adept at implementing the curriculum in the way that it was designed. A *frustrated methodologist* refers to a teacher who is resistant to specific curriculum in planning and also avoids implementation of the curriculum. Remillard and Bryans (2004) have similar categories of teachers' curriculum use. They described teachers as *thorough piloting* - seeking to implement the curriculum as designed, *adopting and adapting* - teachers who use curriculum but change them to suit their needs, or *intermittent and* *narrow* - those who are resistant to curriculum in general. Given that all of these studies use three categories to describe the extent in which teachers base their lessons on their curriculum, I will also describe teacher's curriculum use with three categories that I believe capture the ideas shared by many of the categories found in the literature. The categories I have chosen are *following*, *adapting*, and *omitting* and will give specific definitions for each term in the following paragraphs.

Following curriculum implies that teachers use their curriculum as their main guide in designing instruction and make minimal changes when necessary. Researchers indicate that teachers who follow curriculum in designing instruction read more aspects of and in a more careful manner the curriculum than those teachers who adapt or omit (Remillard & Bryans, 2004; Sherin & Drake, 2009). Several researchers have also found that novice elementary teachers, more than experienced teachers follow curriculum materials in planning instruction (Behm & Lloyd, 2009; Borko & Livingston, 1989; Remillard & Bryans, 2004; Sherin & Drake, 2009). Yet in another study, McDuffie and Mather (2009) observed an experienced middle school mathematics teacher follow the curriculum, indicating that following is not restricted to just novice elementary mathematics teachers.

Another type of curriculum use is *adapting*. Adapting curriculum implies that teachers follow the outline of the curriculum, but make moderate to drastic modifications to the materials while planning and implementing instruction. Remillard and Bryans (2004) described two teachers in their study as adapting. These teachers used their curriculum to sequence topics and often used the tasks found in the curriculum, but they also adapted tasks and the presentations of the content in ways they thought were better for student learning. Another example is from Sleep and Eskelon (2012) who studied two teachers who adapted their curriculum by adding a discussion about the procedure for adding and subtracting fractions before enacting the task where no discussion was described in the materials. In reflecting on my own teaching practice I would often consider myself an adaptor. I have found myself using curriculum to guide my instruction, but often make changes to the materials to suit my style of teaching or to better help students understand the content.

The third type of curriculum use is *omitting*, which involves teachers not using certain aspects of the curriculum. These aspects could be excluding certain words or numbers on a problem, excluding whole problems or problem sets, or ignoring the curriculum entirely. While one might think this is a type of adapting based on several of the terms in the literature involving excluding curriculum I choose to keep the terms separate. Omissions involve the exclusion of material while adaptions are made when materials are changed not excluded. Several researchers have found that teachers when given a conceptual learning based curriculum will not use the materials at all or only use them minimally (Behm & Lloyd, 2009; Manouchehri & Goodman, 1998; Remillard & Bryans, 2004). Manouchehri and Goodman (1998) investigated 66 teachers' use of a conceptual-based curriculum and found that after five months of having the materials 44 of the teachers had either stopped using the materials completely or were only minimally using the materials. Remillard and Bryans (2004) had similar findings and described how two of the eight teachers in their study relied more on their own plans and activities rather than their curriculum in preparing and enacting instruction. These two studies also indicate that experienced teachers may be more likely to omit material than novices, yet other studies have shown that novice teachers omit curriculum at times as well. Behm and Lloyd (2009) found that one of the three novice teachers in their study omitted several aspects of the curriculum and often developed their own materials to use instead.

Curricular Decisions

While much has been learned about how teachers use curriculum materials by categorizing teachers as *followers, adapters*, or *omitters*, (Lambdin & Preston, 1995; Remillard & Bryans, 2004; Stein et al., 2007), even more could be learned if specific teacher decisions and reasoning for using or not using curriculum were studied in depth. In the following sections I discuss why studying teachers' specific curricular decisions and their reasoning is important, as well as discuss the research conducted in this area.

Teachers' Different Roles When Using Curriculum

While individual teachers have been categorized into one type of curriculum user, it raises the question: Can a teacher be categorized as multiple types of users, for example an adaptor and omitter? In examining particular decisions that teachers make when planning, researchers have found that an individual teacher can take on all the roles of follower, adaptor, or omitter depending on the situation (Brown, 2002; Lloyd, 2008; McDuffie & Mather, 2006). Lloyd (2008) described how a student teacher, Anne, took on different roles in designing instruction, depending on which curriculum materials she used. She used two different curricula (*Every Day Mathematics* (*EM*) and *Mathematics their Way* (*MTW*)) as resources in designing her instruction. Anne consistently adapted her *EM* materials and almost always omitted her *MTW* materials demonstrating that she was both an adapter and an omitter. The differences in curriculum use by the same teacher does not only occur when a teacher uses multiple curricula, but variations of curriculum use have been observed in teachers who use a single curriculum (Brown, 2002; McDuffie & Mather, 2006). McDuffie and Mather (2006) described how the teacher in their study generally tried to follow her curriculum but would occasionally depart from using her materials and create her own tasks or lessons indicating that she was both a follower and an omitter. Brown (2002) observed that two teachers in his study would take on the roles of both adapter and omitter while planning instruction. I have found in my own practice that I have taken on all three roles when I make specific decisions as well. Often I make adaptations to curriculum materials to suit my needs, but at times I have found myself either following the curriculum closely or throwing it out altogether.

Differences in Omitting and Adapting

Not only can teachers take on multiple roles of curriculum users (e.g., omitter, follower, and adapter), but the ways in which teachers omit and adapt can vary considerably. When teachers omit curriculum they may choose to omit only particular sections, certain aspects of a section, or the entire lesson. For example, I taught a lesson where I decided to omit two questions on a worksheet and an activity I disliked, while in another lesson I decided to omit a worksheet completely. Likewise, if teachers omit material then they must choose whether to replace what they omitted and decide where to find replacement materials.

The ways in which teachers adapt curriculum can vary greatly as well. Teachers may choose to reorganize lessons, change values of certain numbers, or use supplemental materials. Brown (2002) described how two science teachers (Janet and Bill) made different adaptations to the same lesson on measuring sun light. The curriculum had teachers first give devices to the students to measure light, have them collect data, and then to hold a discussion to connect the data they collected with the underlying phenomenon. Janet adapted the materials by having her students construct their own light measuring devices instead of giving them devices to use. She also had them discuss how the phenomenon related to their experiment during their data collection session rather than after all the data were collected. Bill made three noteworthy adaptations to the curriculum. He redesigned the light measuring apparatus in a way that made collecting data easier, he presented a demonstration before students began data collection, and he also displayed a diagram not found in the material describing the phenomenon they were studying during their discussions. These differences in how teachers omit and adapt curriculum materials can significantly change students' learning opportunities in mathematics.

Curricular Reasoning

Just as important if not more important than knowing the different type of decisions teachers make when using curriculum is understanding teachers' *curriculum reasoning,* which Breyfogle, Roth McDuffie, and Wohlhuter (2010) define as "the thinking processes that teachers engage in as they work with curriculum materials to plan, implement, and reflect on instruction" (p. 308). By understanding teachers' curricular reasoning (i.e., why they make the decisions they do), researchers can understand why teachers make the decisions they do. For example, if it was known that a teacher decided to omit a worthwhile mathematical topics because he had insufficient content knowledge to understand the topic himself (as did some of the teachers described in Manouchehri and Goodman (1998)), his decision to omit would likely be less productive in building student understanding than a decision to omit a topic because it does not align with an overarching mathematical goal for students.

Research on Curricular Reasoning

While there are some studies that explicitly use the idea of curricular reasoning, few actually analyze teachers' curricular decisions or the reasoning behind these decisions. Instead, researchers have attempted to build teachers' curricular reasoning skills. McDuffie and Mather (2009), used a professional development training to identify what kinds of activities teachers engaged in when they made decisions regarding curriculum. In observing two seventh-grade teachers plan and reflect together the researchers found that teachers resorted to the following activities in order to help them make decisions about the curriculum: (a) analyze curriculum from a learners' perspective, (b) do the task together as learners, (c) revise plans based on work with students during instruction, and (d) map learning trajectories (McDuffie & Mather, 2009). While this study does aid in presenting some activities to guide teachers' planning processes little information was provided about the specific decisions teacher made in a non-professional development situation or why they made the decisions they did.

Breyfogle et al. (2010) claimed that their study was about curricular reasoning, but provided little insight into how teachers reasoned about their curriculum. In this study, the authors designed a professional development program to aid teachers in curricular reasoning activities described in McDuffie and Mather (2009). Some of the practices included in the professional development were having discussions about *records of practice* (vignettes of different teaching situations) or analyzing textbooks to understand how mathematics built over time. While the authors concluded that the teachers were now better able to reason about their curriculum materials in developing instruction, little could be gleaned from this study in understanding why teachers made the decisions they did.

While these studies on curricular reasoning did not explicitly address teachers' decisions nor their reasoning about curriculum when making these decisions, I believe that a decision-making framework developed by Schoenfeld (2011) can be applied to understand teachers' decisions for using curriculum in different ways. In the following section I describe Schoenfeld's framework and how it was used in my study.

Schoenfeld's Decision-Making Framework

Schoenfeld (2011) suggests that people constantly make decisions**.** Every day we decide what clothes to wear, what to talk about at lunch, and teachers decide what content to teach and how to present it. Some of these decisions Schoenfeld (2011) defined as routine and occur subconsciously. These decisions usually arise when people are in familiar situations (e.g., someone choosing to eat their usual cereal in the morning, a teacher deciding which examples to show in class). Other decisions are non-routine and come into play when people make decisions in unfamiliar situations. These decisions generally take more thought than routine decisions (e.g., someone deciding to eat something different for breakfast because it is his birthday, a teacher is asked a question that she had not anticipated). Decisions may also vary in how they affect the person making the decision. For example, choosing whom to marry may have a more significant impact on the decision maker than deciding which pair of shoes to wear for the day. Yet given the variety of decisions someone can make, Schoenfeld (2011) claims that all decisions can be understood in terms of a person's orientations, goals, and resources. Schoenfeld describes that orientations, goals, and resources are all interrelated in how they influence decisions as well as each other. This is especially true when long term orientations, goals, and resources are influencing more reasonings. However, Schoenfeld also describes that for specific decisions their influences can be analyzed in a linear progression to understand these decisions. Given that I will be looking at specific decisions teachers make I will focus on Schoenfeld's linear progression or decision making process which my interpretation of is shown in Figure 3.

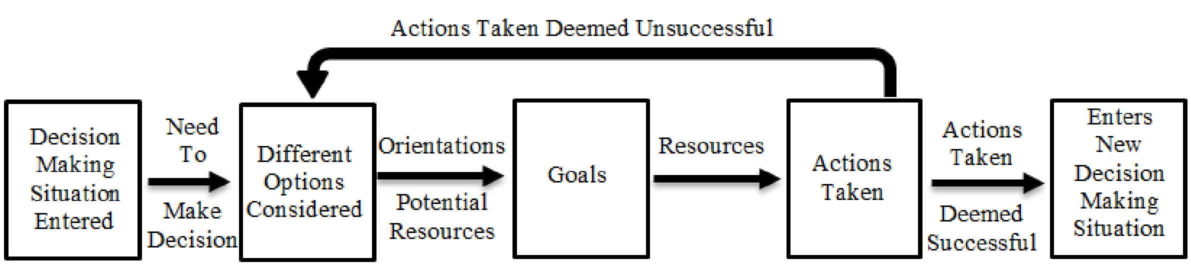

Figure 3. Schoenfeld's Decision-Making Process.

The decision-making process occurs when a person enters a situation where there are different courses of action that a person must choose. Given a need to choose among the different options the person considers different options and the possible results of each option. When considering the different options, the persons' orientations and potential resources influence the person in choosing an option. Orientations—a person's attitudes and beliefs towards objects, people, or ideas— help the person decide which options are more preferable and would give the person the most satisfaction. Resources—the tools available to someone to accomplish a particular task and potential resources, or the resources a person predicts will be available to them at a later time. Potential resources allow the person to identify which options are feasible and which options are more difficult to accomplish. The person then weighs the options and chooses the option that seems most optimal given the potential satisfaction and the difficulty and feasibility of implementation. Schoenfeld (2011) describes the option chosen as the goal, the thing, or task that the person wants to accomplish. Once this goal is chosen the person then begins to use the resources available to them and takes actions to accomplish the desired goal. Once actions are taken, the person then considers whether their actions are successful or unsuccessful. If their actions are deemed successful they then move to a new situation where other decisions must be made. If the actions were deemed unsuccessful, the person then goes back to considering different options and goes through the process again.

While Schoenfeld (2011) claims this process can be used to describe all decisions, he also suggests that this process is more apparent for non-routine decisions than for routine decisions. He explains that because routine decisions are made so often, many of the steps in the decision-making process (e.g. sorting through goals, potential resources, and choosing which actions to take) are done subconsciously. Because the decision maker is unaware of this process for routine decisions, it is difficult for them to explain their reasoning for making the decision. This means that an observer would need a solid understanding of the person's orientations, goals, and resources to infer what led the person to make the decisions that they did. For example, one routine decision that I make every day is deciding the route I am going to take to school. If someone were to ask me why I took my normal path to school one day, my answer would most likely be something like, "this is the path that I always take", or "I don't know, I just like this one." These answers do not give much information about my reasoning and an observer would have to get me to remember why I chose this path in the first place to understand my decision or at least be familiar enough with my reasoning patterns to infer why I chose this path.

On the other hand, when people encounter non-routine situations the steps in the decision-making process become more explicit. The decision maker is more likely to consciously consider the pros and cons (using orientations and potential resources to sort between options) of different decisions they make and explicitly think about the actions they are going to take. For example, consider a teacher using unfamiliar curriculum to plan a lesson. The decision-making situation she enters could be the act of completing her scan of a section of the textbook and must now consider multiple options of how to use the textbook. She could follow her textbook and try to use everything the lesson contains. She could use only the parts of the lesson that she thought were good. She could use some of the aspects from the textbook, but also draw from internet resources. Or she could throw the textbook out and design something entirely different. She draws on her orientations that students should learn meaningful mathematics and should not deal with learning things of unimportance. She considers what she has read in the textbook (a resource) and feels there are some good aspects in it. Thus, she leans more towards using a part of the textbook lesson, and uses the internet to find supplementary materials. She then considers her other available resources. Does she have time to find something on the internet? Does she know of any particular sites that would be useful? In our case, let us say she has some time and is aware of multiple sites, and decides to use part of the material from the textbook and part of the material from the internet. This option now becomes her goal and she begins taking actions to accomplish her goal. She more carefully goes over the textbook lesson and chooses which aspects she wants to use. She also begins searching some of the internet sites she is familiar with to find other materials. These actions are taken because she has the resources of the textbook, time to search, a computer, knowledge of different websites, and knowledge about how to interpret the material she comes in contact with. As she completes her actions she feels that the materials she found will help accomplish her goal and runs into no problems and therefore accomplishes her goal, allowing her to move on to other decisions.

Schoenfeld (2011) suggests that all decisions can be understood in terms of a person's orientations, goals, and resources. This occurs because orientations influence a person in choosing a goal or goals, which then gives motivation for individuals to take actions or make choices, and resources aid in choosing goals and accomplishing actions. Given the importance of orientations, goals, and resources in decision-making I describe each of these factors, provide examples from research on curriculum use of how these factors affect decisions, and outline how I used them in my study.

Goals

Goals are the driving force behind decisions (Schoenfeld, 2011) and they can vary in scope and influence. Some goals are long term (e.g., wanting to become a doctor) and some are immediate (e.g., deciding what song to listen to as you commute to work). Different goals can work together in driving actions. For example, a teacher may have the long term goal of students connecting mathematics to the real world and may have the short term goal of students learning quadratic equations, thus may decide to invite a physicist to come talk to her students about projectile motion. Goals can also contradict each other, which causes decision makers to rely on their orientations in deciding which goals are more relevant. For example, suppose your mother places a large piece of cake in front of you that she made special for you. You may have the goals to eat only healthy food and to please your mother, and therefore you must choose between which goal is more important.

The impact of goals on decisions of what to teach can also be seen in the literature on curriculum use. Sleep and Eskelon (2012) described how two teachers' teaching practices reflected their goals for instruction. For a specific lesson, one teacher Waleska, had the goal for students to conceptually understand the meaning of adding and subtracting fraction and to connect this topic to content discussed in previous classes. Waleska's decisions reflected this goal because she used activities that incorporated student thinking, caused students to productively struggle, and connected mathematical topics – three practices that build conceptual understanding. Another teacher, Marie, taught the same lesson yet, had different goals for the lesson. Marie had the goal for students to accurately use algorithms for adding and subtracting fractions. Her goal too was reflected in the actions she took during instruction. Her lesson consisted of repeated drills of the algorithm that she wanted students to learn. McDuffie and Mather (2009) described a teacher, Lerenze, who had a goal of getting her students to incorporate more problem solving into her instruction. This goal drove her to include a problem-solving activity once a month that was not found in her curriculum.

Establishing clear mathematical goals to teach for understanding. By having clear mathematical goals in planning, or goals about what knowledge, understanding, and skill students' should obtain, teachers are better able to design instruction that leads to the achievement of those goals (Hiebert, Morris, & Glass, 2003; NCTM, 2014; Sleep, 2012; Wiggins & McTighe, 2006). Hiebert et al. (2003) described that when teachers have specific goals they are able to evaluate whether specific instructional activities are likely to aid in accomplishing those goals. Likewise, Wiggins and McTighe (2006) claim that when teachers do not have clear mathematical goals to guide their instruction, the decisions they make are based on just covering specific content topics or incorporating specific activities and are unlikely to lead to student understanding.

Mathematical goals are also necessary for teachers trying to improve their instruction (Hiebert & Morris, 2012; Hiebert et al., 2003). Hiebert et al. (2007) suggested that teachers cannot determine if their instruction was successful or not without having some goal or expectation to use as a measure of success. Hiebert et al. (2003) made a similar claim and added that the more specific a goal is the easier it is to tell if one is successful or not. If teachers do not know whether instruction was successful or not, they will not know which aspects of their teaching to change or which aspects to continue implementing to make learning more successful. McDuffie and Mather (2009) describe a teacher who had the goal of building her students' understanding of angles. To do this she adapted her curriculum to focus on the meaning of angles and enacted her lesson. After instruction she reflected on her lesson and found that the students still did not understand angles as well as she hoped. Because of her students' lack of understanding she adapted her plans again to help her students gain a clearer understanding of angles.

Students benefit directly from the mathematical goals that teachers use to plan and direct their instruction. NCTM (2014) recommends that when students have an idea of the mathematical goals behind learning certain content then they are more willing to become involved in learning activities and are better able to connect new content with previously learned content. If teachers do not have explicit mathematical goals of what they are teaching, then students will have greater difficulty in determining the purpose of lessons and will not be as willing to participate in learning activities and are less likely to see connections in mathematics.

Orientations

Another important factor that affects the decisions people make are their orientations or their attitudes or beliefs towards something (Schoenfeld, 2011). Schoenfeld (2011) describes that when a person enters a situation where a decision must be made, his orientations begin influencing him in deciding what possible outcomes seem optimal given the situation. Ultimately, orientations along with potential resources lead to a goal or goals being chosen and actions being taken. The author also claims that people may not be aware that they have certain orientations. For example, a teacher may think he has an orientation to use student thinking, when in fact he rarely asks questions that elicit student thinking. Because of this phenomenon, Schoenfeld (2011) claims that orientations should be identified through the observation of consistent patterns in teachers' actions and not by what teachers say they believe.

Several researchers have also indicated that orientations are influential in how teachers use curriculum materials (Manouchehri & Goodman, 1998; Remillard & Bryans, 2004; Sherin & Drake, 2009; Sleep & Eskelson, 2012). In particular, teachers' orientations towards curriculum materials, teaching, and learning have been found to be significant factors in influencing teachers' curriculum use (Remillard & Bryans, 2004; Schoenfeld, 2011).

Orientations towards curriculum materials. Teachers' orientations towards curriculum affect the ways in which they use the materials (Manouchehri & Goodman, 1998; Remillard &

Bryans, 2004; Sleep & Eskelson, 2012). Remillard and Bryans (2004) found that the teachers observed in their study viewed the purpose of curriculum differently and therefore used them in different ways. The authors found that some teachers viewed curriculum as a guide in planning instruction, some viewed it as supplementary material and used it to enhance materials that they had used previously, and others viewed curriculum as a way to improve their own understanding of mathematics and used them accordingly.

Researchers indicate that teachers' orientations towards specific curriculum affect the way they use them (Ball & Feiman-Nemser, 1988; Lloyd, 2008; Remillard & Bryans, 2004). For example, Lloyd (2008) described how one teacher had a positive orientation towards one curriculum and used it frequently while she displayed a negative orientation towards the other curriculum and rarely used it. Researchers also indicate that when teachers have negative attitudes towards specific curriculum they are much more likely to omit the curriculum completely or resort to materials that they have used in the past or created themselves (Ball & Feiman-Nemser, 1988; Manouchehri & Goodman, 1998; Remillard & Bryans, 2004).

Orientations towards teaching mathematics. A teacher's orientation towards teaching mathematics or a teacher's view of his role as teacher also influences the way he will use curriculum (Remillard & Bryans, 2004; Schoenfeld 2011). Remillard and Bryans (2004) found that teachers can have differing views of their roles as teachers. Teachers may view their role as someone who should teach skills, or as someone who provides environments where students can learn on their own, or as a leader of discussions. Schoenfeld (2011) described that teachers may actually have multiple orientations towards teaching and described one teacher as having orientations to give students opportunities to make sense, ask questions that show student understanding, and praise students' initiative, understanding, and ideas and these all influenced the teacher's decisions about instruction.

Orientations towards teaching also include teachers' orientation towards certain teaching practices or student behavior (Schoenfeld, 2011). For example, a teacher may not use practices that allow students to discuss and explore mathematics on their own, because they believe that students should be working quietly. On the other hand a teacher may have the orientation that students should discover all mathematics by themselves and therefore, provide no help to students at all (Usiskin, 2014a).

Orientations towards learning mathematics. Teachers' orientations towards learning mathematics also influence the ways in which teachers use curriculum (Remillard & Bryans, 2004; Schoenfeld 2011). Orientations towards learning are the beliefs and attitudes teachers have about how others learn mathematics. While there are several different theories about how people learn (e.g., constructivism, behaviorism, situated cognition), Hiebert and Grouws (2007) indicated that the two main ways in which teachers' view learning mathematics are: learning in order to gain procedural skills and learning for conceptual understanding. Sleep and Eskelson (2012) investigated these two views of learning and their effects on learning. One teacher, Marie, believed that the purpose of learning mathematics was to get students to understand and be able to perform procedures. The other teacher, Waleska, had the orientation that learning mathematics was about understanding concepts and not memorizing formulas and building skills. The teachers' orientations towards learning mathematics were evident in their teaching as Marie taught in a manner that built procedural skills, while Waleska taught in a manner that built understanding.

Resources

Schoenfeld (2011) described resources as the tools available for a person to achieve a particular goal. Resources may be non-tangible objects such as time or knowledge or they may be physical materials such as money, calculators, and computer software. The author described that knowing what resources are available aids a person in choosing a goal as well as allowing them to take a certain action. For example, if I am deciding what content I want to teach I would look at the different options available and see if I had both the curriculum and the knowledge (or potential source of knowledge) to teach the topic. I would also have to draw on these resources as I plan for the topic. Two of the resources that seem most influential in how teachers make decisions about curriculum are the specific curriculum themselves and their mathematical knowledge for teaching.

Curriculum materials. There are several curricula resources teachers can draw on once they decide on the goals they want to have and in taking actions. Researchers claim that the most common curriculum resource used to make decisions about instruction are textbooks (Ball & Feiman-Nemser, 1988; Tarr et al., 2006). Other sources that can aid teachers in making decisions are materials found on the internet, teacher created materials, manipulatives, state or national standards, pacing guides, and supplementary materials. All of these resources vary in the amount of teacher support they provide, the types of activities available, and the sequencing of different topics.

Knowledge. Schoenfeld (2011) claimed that the resource that generally influences decisions the most is knowledge. Researchers on curriculum use have also identified knowledge as a key factor that influences teachers' curriculum use, specifically their knowledge of content, curriculum, pedagogical practices, and students (Ball, Thames, & Phelps, 2008; Grossman, 1990;

NCTM, 2000; Shulman, 1986). In the following paragraphs, I discuss each of these types of knowledge and indicate what effects they may have on teachers' curriculum use.

Knowledge of content. Teachers' content knowledge or teachers' knowledge of and about mathematics is an important resource that influences teachers' decisions about curriculum. Several researchers claim that in order to teach effectively teachers must not only be able to successfully complete all the activities and assignments that they give their students, but they must also have a deep understanding of how the mathematics works, as well as be able to interpret different methods students use in working with the mathematics (Ball et al., 2008; NCTM, 2000; Shulman, 1986). Ball et al. (2008) described how teachers' mathematical content knowledge allows them to be more productive when working with materials, make fewer mistakes in calculations, answer questions more accurately, and better interpret student responses. Many of the benefits associated with teacher content knowledge can be seen in the literature on teacher curriculum use. Winiecke (2015) described how a high school teacher, Peter, teaching calculus for the first time often struggled to understand the content presented in his curriculum. In order to compensate for his lack of understanding he worked example problems from the textbook, consulted other teachers, and searched online for explanations. Had Peter had a better understanding of the content, he could have used his planning time to focus more on other aspects besides building his own understanding. Two other studies (Manouchehri & Goodman (1998) and Sherin & Drake (2009)) found that several teachers omitted certain topics of their curriculum because they did not understand the content.

Curricular Knowledge. Curricular knowledge is a resource that refers to knowledge of the different resources available for teachers to plan instruction as well as knowledge about content students have learned in previous classes and the content they will learn in future classes

(Ball et al., 2008; Shulman, 1986). Shulman (1986) argued that teachers should be familiar enough with their curriculum that they know the strengths and weaknesses of the materials and are aware of other sources they can use to compensate for perceived weaknesses in the materials. Drake and Sherin (2009) described a teacher who in her first year of using a particular textbook made several adaptations due to weaknesses she perceived in the materials. The following year, when she was more familiar with the materials, she decided the weaknesses she perceived at first were trivial and began to follow her curriculum more. Winiecke (2015) described a teacher who tried following her curriculum materials one year, but due to a lack of practice problems in the curriculum, she searched for example problems on the internet and from problem generating software.

Researchers also indicate that having a knowledge of what students learned in previous classes and what they will learn in future classes is important to planning (Ball et al., 2008; McDuffie & Mather, 2009; Shulman, 1986). By having an understanding of what students have learned previously and what content students will learn in the future, teachers can select content that students are capable of understanding and give them a knowledge base for future instruction. For instance, McDuffie and Mather (2009) described how two teachers felt they needed to add supplementary instruction on incidence and reflection because students had not previously learned this material, but would be expected to be familiar with this content in future instruction.

Pedagogical content knowledge. Pedagogical content knowledge is the knowledge required specifically for teaching (Shulman, 1986) and consists of knowing what representations, activities, and tasks are appropriate and productive for a given situation. Researchers have noted that elementary students have misconceptions of the equal sign (e.g., students view the equal sign as an operation to compute rather than as a symbol that denotes equivalency) (Carpenter, Franke, & Levi, 2003; Knuth, Alibali, McNeil, Weinberg, & Stephens, 2005), yet there are certain strategies teachers can use to help students overcome these misconceptions. Carpenter et al. (2003) claims that using different true/false questions with different types of equations that use the equal sign and discussions about these questions as well as using the language "same as" in talking about the equals sign can aid students. Understanding these strategies are a form of pedagogical content knowledge because they relate specifically to the teaching of content rather than the content itself. Another example considers the different representations used to explain the meaning of an integral. Jones (2015) indicated that students can view integrals as an area under a curve, as an anti-derivative, or as adding up pieces, but that the adding up pieces representations makes more conceptual sense to students and aids them when working on applied integral problems. This is a form of pedagogical knowledge, because it relates specifically to the teaching and learning of integrals.

Knowledge of students. Knowledge of students is a resource that involves teachers being aware of students' understanding of different topics and anticipating obstacles that may hinder students from learning current or future content. NCTM (2000) suggests that students learn mathematics by connecting new concepts and ideas to concepts and ideas that they previously learned. In order for students to learn new concepts they must have appropriate prior knowledge. Therefore, teachers need to be aware of students' understanding of prior concepts before deciding to introduce new content or not. For example, a teacher should be confident that students understand addition, before they teach their students multiplication, because multiplication builds on ideas of addition.

Content

For my study I will focus specifically on a mathematical content area that the teachers in my study will be unfamiliar with. Borko and Livingston (1989) and Winiecke (2015) have indicated that when teachers plan lessons for content that they have taught in previous years they tend to use their notes from previous years to plan their instruction, rather than original curriuclum. Schoenfeld (2011) also indicated that the decision-making process for routine decisions often occurs unconsciously and is more difficult to understand than the decision-making process for non-routine decisions. Therefore, to investigate teachers' decisions as they use curriculum I provided teachers with curriculum that they were not familiar with which required them to consciously make decisions.

A content area that middle grades mathematics teachers are likely to be unfamiliar with are geometric transformations. Teuscher, Tran, and Reys (2015) indicated that one of the most significant changes from previous standards to the *Common Core State Standards for Mathematics* or *CCSSM* (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010) is the inclusion of geometric transformations in the middle grades. The authors indicated that some of these changes include: teaching geometric transformations in middle school rather than in high school, learning transformation before congruence and similarity rather than after, using geometric transformations on coordinate planes, and using transformations to define congruence and similarity.

Besides being a new topic in the middle grades, most textbooks do not represent content about geometric transformations in a way that is conducive to learning. For example, Kasmer, Teuscher, Dingman, & Olson's (2015) analysis of multiple middle school textbooks found that many commonly used textbooks did not include content about orientation of geometric figures in the geometric transformations unit and that those that did, did so innacurrately. This is important because the orientation of a figure is one of the three main properties that should be discussed in analyzing geometric tranformations (Kasmer et al., 2015). Likewise, glide reflections, another useful topic for understanding geometric transformations, are not included or portrayed inaccurately in middle school mathematics textbooks (Usiskin, 2014b). The *CCSSM* (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010) describe that congruence between two objects can be shown by mapping a preimage to an image through a sequence of reflections, rotations, and translations (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010). However, a sequence of reflections, rotations, and translations will always lead to one of the following transformations: reflection, rotation, translation, or glide reflection. These four transformations are isometries because they preserve the shape and size of the preimage. Therefore, congruence can be shown through a single tranformation meaning that any congruent image can be mapped to a preimage through a single reflection, rotation, translation, or glide reflection (Usiskin, 2014b). This means that if students know the specific properties of each type of geometric transformations (e.g. preservation of orientations, preservations of angles, and preservations of distance) they can easily determine whether figures are congruent. Given the weaknesses of new textbooks in these two areas it seems there are ample opportunities to learn about teachers' decisions when planning for lessons related to geometric transformations as well as their reasoning behind their decisions.

CHAPTER 3: METHODOLOGY

In this chapter I detail how I collected data in order to investigate teachers' curricular decisions and the reasoning behind the decisions as teachers planned using unfamiliar curriculum materials. First, I describe the participants of the study and how they were recruited. Second, I describe the different instruments I used to gather data. Lastly, I outline how I analyzed the data to answer my research questions.

Participants

I selected two novice grade 8 mathematics teachers and one experienced grade 7 honors mathematics teacher who taught grade 8 content as participants for my study. I selected these teachers because geometric transformations, the mathematics content focus of my study, is a "new" content that most grade 8 teachers have not taught or only taught in the last year or two.

In order for a teacher to be considered as teaching grade 8 content for geometric transformations the teacher had to be teaching the standards that aligned with either the *CCSSM* (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010) or the *Utah Core Standards* (Utah State Board of Education, 2010). At the time of this study these documents had similar wording for the grade 8 geometric transformations standards. The one difference between the two documents that may influence teachers is that the *Utah Core Standards* contains links to tasks and other resources related to each standard while the *CCSSM* only includes the standards.

I included novice teachers in my study for three reasons. First, novice teachers have less experience in making decisions with curriculum in general (Borko & Livingston, 1989). Consequently, the decision-making process they go through during planning is likely to be non-routine and more explicit, which will provide rich data to analyze (Schoenfeld, 2011). Second, novice teachers, more than any other subsets of teacher, have to plan lessons with unfamiliar curriculum materials given that they do not have previous lesson plans to rely on. Many experienced teachers may not plan with curriculum such as textbooks or online materials at all, but resort to using lesson plans (e.g., notes, outlines, tasks) from previous years (Winiecke, 2015). On the other hand, novice teachers typically have no previous lesson plans to work with and resort to initially starting with the curriculum to plan. Therefore, researching novice teachers' decisions when using curriculum to plan for instruction is more relevant and applicable than researching other subsets of teachers. Third, given that novice teachers use curriculum in their planning anyways, having unfamiliar curriculum materials to plan lessons – a significant aspect of my study – is less intrusive for novices than for experience teachers. Because geometric transformations are a relatively new content in the middle grades curriculum I believe that this content may be harder for novice teachers to sort through and that the decisions of novice teachers could vary based on their mathematical content knowledge.

While there are advantages to having novice teachers in this study, I also recruited one experienced teacher for my study. Experienced teachers generally have greater knowledge of content, curricular knowledge, pedagogical knowledge, and knowledge of students. Given that knowledge is a resource that is influential in making decisions (Schoenfeld, 2011), it is likely that novice and experienced teachers will make different decisions in planning instruction based on their knowledge. Thus, in order to understand the possible variation in how novice and experienced teachers plan based on their resources they have available, I included one experienced teacher in my study for comparison.

Selecting Participants

In order to identify possible novice teacher participants, I met with the faculty member of BYU's mathematics education department, who oversaw student teachers during the previous school year, and determined which of these students were currently teaching in locally. Once I had composed a list of local first year teachers I identified those who taught grade 8. I then met with faculty members of BYU Mathematics Education department who had taught these teachers as undergraduates to recommend students they thought would be willing to participate in my study.

In order to identify an experienced teacher for my study I asked faculty members for recommendations for local experienced grade 7 honors or grade 8 mathematics teachers. Once I had a pool of possible participants I emailed each of them, and set up a time to meet with those willing to participate. The first meeting was to introduce myself, the study, describe the requirements for them to participate in my study, and answer any questions. Some of the topics addressed in these meetings were: the purpose of my study and what I hoped to learn, the methods I would use to gather data about their lesson planning process, what interviews would be like, possible scheduling of interviews, their past experience in teaching and learning of geometric transformations, as well as any concerns or questions from the teachers. At the end of our discussions I asked them if they would be interested in participating and if so, set up a time for our first interview. After conducting four meetings, two novice and one experienced teacher agreed to participate in the study.

Data Collection

One of the main sources of data collection for my study were semi-structured interviews about the teachers' plans for upcoming lessons. I interviewed each teacher after they had planned their lessons, but prior to them teaching the lesson. I interviewed teachers once about a lesson plan of their choice not related to geometric transformations and the rest of the interviews revolved around their lesson plans for 2-5 lessons in their geometric transformation unit. Each semi-structured interview ranged from 30 minutes to an hour and was video recorded for analysis. Because researchers have indicated that teachers constantly make mental changes to their plans up until the time of instruction (McCutcheon, 1981), I conducted the interviews as close to when their lessons were taught as possible (e.g., the morning before or the day before the lesson actually was taught). The focus of the interviews was to gather data on individual teacher's decisions and reasoning when planning with curriculum. In general I sought to understand what decisions teachers made with their curriculum as well as their orientations, goals, and the different resources they used to aid them in making decisions. In order to get at these ideas I modified an interview protocol designed by J. Choppin's (personal communication, April 15, 2015) to address these topics specifically. The interview protocol was organized into eight interview topics (see Appendix A) and Table 1 displays how each of the questions addressed the different domains of interest needed to answer my research questions. Because my protocol asked some questions related specifically to the lesson plans that teachers designed, I modified the protocol for each lesson the day prior to each interview but only after I analyzed the teachers' lesson plan outline.

Table 1

Interview questions and how they relate to research questions

Domains needed to answer research question	Interview Questions
Teacher Decisions and Reasoning	2, 3, 4, 5, 6, 7, 8
Goals	2, 3, 4, 5, 6, 7, 8
Orientations	1, 2, 3, 4, 5, 6, 7, 8
Resources	2, 3, 4, 5, 6, 7, 8
Mathematical Goals	6

Lesson Plan Outline (Appendix B). The day prior to the scheduled interview teachers completed a lesson plan outline, which was an online google survey (Google, 2007) (see Appendix B) about their plans for the upcoming lesson they were teaching. The lesson plan outline prompted teachers to provide information about the mathematics content and goals of the lesson, any resources used in designing the lesson, and a list of the activities and examples they planned to use with their students. By knowing about the specific mathematics content, goals, resources, and activities the teacher planned to address before the interview took place, I planned interview questions related to specific topics for each teacher.

Highlighted Curriculum. Another source of data that I collected and analyzed to answer my research questions were highlighted curriculum on geometric transformations. Before the teachers began planning their lessons on geometric transformations I gave them several copies of chapter 4 of *The University of Chicago School Mathematics Project's* geometry textbook (*UCSMP*) (Benson et al., 2016) and asked the teachers to look over the materials and incorporate them in any way they saw fit, which could include not using the curriculum at all. I also asked them that as they planned with the *UCSMP* curriculum to highlight anything that they read and that I would pick these materials up the day before each interview. By knowing which parts of the materials the teachers read, I planned to ask them why they read certain parts over others as well as identify in the analysis which aspects of what they read did they follow, adapt, and omit.

I provided copies of the *USCMP*'s geometry textbook chapter (Benson et al., 2016) specifically because it gives an accurate definition of important geometric transformation concepts, as well as it being a high school textbook. In Benson et al. (2016) both topics, the orientation of figures and glide reflections are defined in a manner that can aid students in understanding (i.e., thinking about the orientations of points as you walk clockwise or counterclockwise around a polygon and glide reflections are used to show that any two congruent figures can be mapped to one another using one transformation). This textbook was also designed to be used in high school and not middle school and therefore covers content or present it in a way that is not suitable for middle school students. Giving teachers this curriculum provided another opportunity to see how teachers adapted the materials to suit the needs of their students; teach it as is, which may confuse middle school students; or not use the materials entirely.

Data Analysis

In order to answer my research questions, I gathered data that I used to identify the teachers' instructional decisions and infer the teachers' reasoning. In order to do this, I conducted an analysis of the teachers' lesson plans prior to each interview and conducted a more extensive analysis of the teachers' lesson plans, interviews, and highlighted curriculum materials after all the data were collected.

Pre-Interview Preparations

In developing my interview protocol for each prepared lesson I did a quick analysis of the teacher's lesson plan outline (see Appendix B) and the highlighted curriculum. Specifically, Questions 4a, 4b, 4c, and 7a of my interview protocol focus on why teachers made particular decisions. In order to collect useful data from these questions I needed to have particular decisions in mind to ask teachers in the interview. To complete the initial analysis I went through three phases. An overview of these phases is in Table 2.

Table 2

Overview of Pre-interview Preparations

Phase	Details of each Phase
1	Identify teachers' decisions in lesson plan outline
2	Label each decision as an instance of *following, adapting, omitting,* or other/self-create
3	Update interview protocol based on individual teacher's lesson plan outline

Phase 1. I read through the teacher's lesson plan outline and identified all decisions the teacher made. I defined a decision as any part of the lesson or the lesson planning process where a different option could have been made (e.g., activities, examples, problems given, mathematical goals, mathematical content chosen, and instances of omitting). I kept track of the different decisions using the decisions sheet (see Appendix C).

Phase 2. The next phase of my analysis was to classify each decision as *following, adapting, omitting,* or *other* In order to do this I reviewed each decision identified in phase 1 and identified how the decision correlated to the teacher's highlighted curriculum. If a decision used the exact wording or problem found in the text I classified the decision as following on the decisions sheet. I made copies of the highlighted curriculum and used a green highlighter on the copied materials on all of the sections where the teacher made following decisions. If a decision seemed to align with the curriculum, but differed from the exact wording or idea of the materials (e.g., changing the numbers, using a subset of problems, using different materials, adding a discussion, or switching the ordering) I classified the decision as adapting on the decision sheet and made a yellow marking of where this happened in the highlighted curriculum. For any adapting decisions, I made notes on the decision sheet of how the materials were specifically adapted. Initially if the decision did not relate to any of the content in the curriculum it was classified as other. Any aspect of the curriculum that the teacher read that did not fall into one of the other categories (following, adapting, or other) was highlighted as red and classified as omitting. Because the teachers all decided to omit the *UCSMP* curriculum, I began to keep records of how the teachers followed, adapted, or omitted the other materials they were using.

Phase 3. After classifying teachers' decisions as following, adapting, omitting, and other. I made notes about which decisions in the teachers' lesson plans seemed vague and needed clarification. I also made notes to ask about the reasoning behind each decision in my pre-interview analysis sheet.

Post Data Collection Analysis

After all the interviews were completed I conducted a more detailed coding and analysis of the interviews, lesson materials, and lesson plan outlines to answer my research questions. An overview of this process is in Table 3.

Table 3

Overview of Post Data Collection Analysis

Stage	Details of each Stage
1	Identify instances of a decision and reasoning in the video recorded interviews
2	Label each decision as an instance of *following, adapting, omitting, or other/self-create*
3	Label all reasoning as a *goal, orientation, resource,* or *other*
4	Label all decisions and resources
5	Recoded all instances to make data more reliable
6	Compared individual teacher's decisions and reasoning across lessons as well as across teachers

Stage 1. I used the video analysis software StudioCode (Vosaic, 2015) to identify instances of decisions and reasoning in the video-recorded interviews. I then went through all the lesson plan materials and tasks provided by the teachers and recorded instances of decisions and reasoning. Decisions were defined in the same manner as used in the pre-interview analysis and I defined a reasoning as any explanation for why a specific decision was chosen or any reference

to a goal, orientation, or resource. After identifying these instances, I compiled them into spreadsheets for further analysis.

Stage 2. I then went through all the instances of decisions to label them. Decisions were labeled distinctly as instances of *following*, *adapting*, *omitting,* and *other* and were defined in the same manner as in the pre-interview analysis. I began by coding one interview from each teacher to ensure that my coding was reliable for all three teachers. After confirming that I had clear definitions and knew how to sort the different instances I coded all pre-interviews. In reviewing the different definitions and instances I noticed that most of the *other* instances were similar in that the teachers' decisions involved not basing their decision on any curriculum material, but created the materials themselves. I then changed the other category to the code *self-creating.*

Stage 3. I began by labeling the teachers' reasoning as *orientations, goals,* or *resources*. An *orientation* label was given to any reasoning that I inferred had to do with the beliefs, attitudes, or preferences of teachers. A *goal* label was applied to any reasoning where the teacher specifically stated that she was doing something in order for her or her students to accomplish, in other words when the teacher was seeking a specific result. A *resource* label was applied when the teacher described some object, technology, person, or knowledge or lack of these things in aiding or hindering them in making a decision. Similar to my decisions labels, I coded for resources twice in order to be more reliable and consolidated any redundant reasoning.

Stage 4. In order to sort the decisions, I went back through all the instances and added new labels to describe which aspects of the lesson they addressed. I chose eight labels that seemed distinct for the decision coding and defined these aspects as follows:

- *Sequencing* – Decisions about how to organize the unit and/or lessons within the unit.
- *Mathematical Goal* - The specific mathematical goals that the teacher had for their lesson plans.
- *Activity* – Decisions regarding the inclusions, exclusion, or adaptations of classroom activities.
- *Curriculum Use (UCSMP)* – Decisions regarding how *UCSMP* was followed, adapted, or omitted.
- Curriculum Use (Other) - Decisions regarding how materials other than the *UCSMP* were followed, adapted, or omitted.
- *Planning Process* - Decisions regarding the manner in which teachers planned their lesson (e.g., what materials they reviewed, how they adjusted them, working through the problems).
- *Mathematics* – Decisions regarding how specific mathematics topics were presented (e.g., orientations, or having a discussion about what squaring means).

I also applied labels to the different reasoning based on three types of orientations that emerged from the data. These were:

- *Orientations towards curriculum materials* – refers to the teacher's attitudes, beliefs, or preferences in regard to the curriculum they used.
- *Orientations towards teaching* – refers to the teacher's attitudes beliefs, or preferences of how mathematics was taught or the teacher's view of their role as teacher.
- *Orientations towards learning* – refers to the teacher's attitudes, beliefs, or preferences of how mathematics was learned. This included things such as students need to build knowledge for themselves or students learn best through repetition.

Resource reasoning was given the following labels based on the following eight types of resources that emerged from the data. These were:

- *Curricular Knowledge* – Justification for a decision that involved knowledge of different curricula available or mathematics content that students have learned or will learn in the future.
- *Curriculum* – Justification for a decision that indicated how specific materials the teacher was using influenced their decision.
- *Content Knowledge* – Justification for a decision by describing how the mathematics worked, this could also be incorrect mathematics knowledge.
- *Knowledge of Students* - Justification for a decision based on how the teacher thought students would react to a decision or how students have reacted in the past.
- *Pedagogical Content Knowledge (PCK) –* Justification for a decision that consisted of knowing what representations, activities, and tasks were appropriate and productive for a given situation. Knowing whether a certain task or an activity was productive to build knowledge.
- *Support of Teacher* –Justification for a decision based on whether support or lack of support from other teachers, their department, school, principal, or school district.
- *Technology* –Justification for a decision based on whether a certain technology was available or not.
- *Time* –Justification for a decision based on whether or not teachers had enough time to accomplish something.

Stage 5. After my initial coding of instances of decisions, reasoning, and applying appropriate labels. I went back and coded them all again to verify that my data analysis was consistent and reliable. Any decisions that I still had questions about were discussed with my advisor until we had consensus about how to label them.

Stage 6. I analyzed the data patterns and anomalies of decisions and reasoning for each teacher and then identified patterns and anomalies across teachers. I did this specifically by:

1. Finding the total number of decisions and reasoning each teacher made for each lesson as well as the percentage of each type of decision and reasoning for each teacher.
2. Identified general patterns and anomalies of these labels among individual teachers and went back and checked the anomalies to verify that my coding was correct.
3. I then examined the decisions and reasoning the teachers made in comparison to each other. In comparing the teachers decisions and reasonings I also inferred a simplified linear progression to describe each teacher's decision making process similar to Schoenfeld's decision making process in figure 3. Note that while these processes indicate the teachers reasonings were building off each other in a linear fashion, teacher's reasonings could also be seen as interconnected.

CHAPTER 4: RESULTS

In this chapter I share my findings for the middle school teachers' decisions and reasoning while planning multiple lessons on geometric transformations. First, I describe the teachers' lack of use of the *UCSMP* materials, next I describe the decisions and reasoning for individual teachers while planning their lesson on geometric transformations, last I compare the decisions and reasoning across the three teachers.

Lack of UCSMP Use

One of the biggest surprises about my study was the lack of impact the *UCSMP* materials had in aiding the teachers as they designed their lessons on geometric transformations. All three teachers omitted the examples, homework problems, definitions, and sequencing of the *UCSMP* materials. There was only one teacher who included anything from the *UCSMP* materials in her lesson plans, which was in her composition of transformations lesson. This teacher included the concept that a rotation is a composition of two reflections over intersecting lines.

The teachers all had different reasoning for why they did not use the *UCSMP* materials. One teacher liked the materials, had heard about them before, and indicated that she knew that the materials aligned with research on geometric transformations. However, she chose to use her department materials over the *UCSMP* materials because she had positive orientations towards her department materials – she liked how they were scaffolded, explained things in a way that her students could understand, and because she felt pressure from her department to use their materials. Another teacher decided not to use the *UCSMP* materials because the curriculum did not align with what she wanted to teach. The third teacher did not want to use the *UCSMP* materials because she did not think that the content aligned with the CCSSM (National

Governors Association Center for Best Practices Council of Chief State School Officers, 2010) and the materials were from a high school textbook.

Because the teachers omitted the *UCSMP* materials, very few decisions were made about these curriculum materials and if I only examined their decisions about the *UCSMP* materials I would have little to discuss. On the other hand, although the teachers did not use the *UCSMP* materials, they did draw on and give more consideration to other curriculum resources as they made decisions in planning lessons on geometric transformations. Therefore, I expanded my data collection and analysis to include the teachers' decisions when using the *UCSMP* materials, as well as any other materials that impacted the teachers' lesson plans about geometric transformations.

Teachers' Decisions and Reasoning

In this section, I describe each of the three teachers' decisions while planning geometric transformation lessons and their reasoning for these decisions. I discuss each teacher individually and then I compare across the three teachers. With regards to decisions, I specifically focus on teachers' general curricular decisions about how they used the curriculum materials and then I discuss their specific decisions while planning their geometric transformations lessons. I then discuss teachers' reasoning with respect to how I used the data to infer the influence of their goals, orientations, and resources on their decisions.

Emma

Emma was a first-year teacher who worked at a public junior high in a large school district. She taught mathematics to grades 7 and 8 students as well as a remedial mathematics course for grade 8 students. As a first-year teacher, Emma was required to give pre- and post-assessments for every major concept she taught and was expected to use specific worksheets, assessments, and activities that were created by colleagues in her mathematics department. She also had a classroom set of textbooks available for her and her students, but was encouraged to use the department-made materials over these. Prior to this study, Emma had several experiences learning about geometric transformations and how to teach them. As an undergraduate in mathematics education at BYU Emma had courses that discussed methods for teaching geometric transformations and was exposed to terms such as *orientation*, *isometries*, and *glide reflections*. She also worked as an undergraduate research assistant examining alignment of newer textbooks with the new CCSSM (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010) standards for geometric transformations.

Emma's general curriculum use decisions. Although Emma made decisions in each category of curriculum use, of all the decisions Emma made, her most common curriculum use decision was to follow her curriculum. Specifically, she followed her departmental curriculum materials by using all aspects of these materials as written. Emma's departmental curriculum materials were composed of worksheets and assessments. The worksheets were typically problem sets but also included background information as well as formulas. Appendix D includes an example of a student worksheet Emma used with her students for the lesson on translations of geometric figures. Emma did not make any decisions to include any other curriculum material.

Emma did make several decisions to *adapt* both her department materials as well as other curriculum materials. The majority of Emma's adapting included adding discussion questions to the lesson that were not originally found in the departmental materials. Some of these decisions seemed to be influenced by other resources. For example, one adaption Emma planned was to include a discussion with students where she described the procedure of geometric translations on the coordinate plane as a “code.” The idea of using a code came from another teacher, who described how the term “code” showed up on an end of year assessment. Another example was Emma planned to include a discussion about two reflections over intersecting lines being equivalent to a single rotation after students worked a problem involving composing two reflections. While Emma did not say this directly, it seemed that the inspirations for this discussion came from the *UCSMP* materials, which describe rotations as a composition of two reflections over intersecting lines.

Emma also made adaptions by including discussions that did not come from other curriculum, but were interesting to her. For example, she added a discussion in her composition of transformations lesson about which way a triangle was pointing after it was reflected. Emma noted that this discussion was not about the orientation of a figure, a topic very relevant to understanding transformations and stated that she specifically did not want to use the term orientation. Another example was during her lesson on composition of transformations, she debated whether to include a discussion about how any point could be the pre-image of another point using any transformation. In other words, point (x_1, y_1) could be transformed to point (x_2, y_2) by translating the point, reflecting the point, or by rotating the point.

Another type of adaption Emma made was she created a pre-assessment for her geometric transformation unit using one of the alternate end-of-unit-assessments included in her departmental curriculum materials. She chose three questions from the alternate end-of-unit-assessments to use as a pre-assessment. The first question required students to rotate a triangle 90-degrees about the origin, the second had students translate a triangle on the coordinate plane and identify the new coordinate points, the third question had students identify the coordinates of the vertices of a triangle that was rotated 90-degrees around the origin and then reflected across the x-axis.

Although Emma followed and adapted her materials often, she rarely omitted content. She did end up omitting the discussion about how any point could be the pre-image of another point using any transformation rather than being transformed by one particular transformation. She also omitted the *UCSMP* materials except for the one concept of two reflections over intersecting lines is a single rotation of the figure.

Some of Emma's other decisions, namely the mathematical goals for her lessons did not seem to fit in any of the categories of following, adapting, and omitting. For example, Emma's curriculum materials did not include explicit goals for the lessons and Emma indicated that she chose her goals based on what she found important in her experience. Due to the fact that these goals did not fit into the three curriculum use categories, I created a new curriculum use category *self-create*. I define the self-create category as teachers supplementing their materials by developing different aspects of their lesson plans or student tasks on their own.

Emma's decisions regarding geometric transformations. Emma sequenced her lessons as they were designed by the department in her curriculum materials. Her lessons were organized and sequenced in the following order: (a) translations, (b) reflections, (c) rotations, (d) dilations, and (e) composition of transformations. Emma spent one day on each of these topics. I discuss two of these lessons, translations and composition of transformations, that I gathered data about Emma's lesson plans.

Translations Lesson. Teaching translations Emma focused on what she called the "code" or using the procedure rule $(x, y) \rightarrow (x + a, y + b)$ to translate points on a coordinate plane. All of the problems on the student worksheet either had students graph a translated figure using this “code” or students were to identify the vertices of a translated figure on a coordinate graph. Emma also had students focus on some of the properties of translations in her lesson. After Emma demonstrated the first problem translating a figure according to the “code” for students she planned to have students measure the side lengths and angles of the pre-image and image and discuss their findings. She intended to have students notice that corresponding side lengths and angle measures in pre-images and images were equal. She also had a goal in her lesson for students to know that a translated line will be parallel to the pre-image, however, nothing in the task or lesson promoted students to explore this idea and the goal was given little attention in the interview.

Composition of transformations lesson. In planning compositions of transformations Emma focused on using a series of transformations. In this lesson, she had students work on problems that required them to perform multiple transformations on a coordinate grid. Students would do one transformation at a time and record the new coordinates of the figure with each transformation. Students were also given three images of transformed figures and asked which transformations were used to get from the pre-image to the image and which rules (e.g., $(x, y) \rightarrow (x + a, y + b\ ))$ they used to justify that the transformations were correct. In this lesson, the department materials included some notes about glide reflections. These notes indicated that glide reflections were the composition of a translation and a reflection, but gave no mention why glide reflections were important. Dilations were also included in the composition problems, and Emma planned to discuss how dilations lead to non-congruent figures.

Emma’s reasoning for curriculum use decisions. Emma’s reasoning for her decisions is based on my inferences with regards to Emma’s orientations, goals, and resources. With regards to orientations, I specifically focus on Emma’s orientations towards curriculum, teaching, learning, and mathematics. With regards to goals I focus on both her mathematical goals as well as inferred goals for her lessons. In discussing her resources, I focus on her curricular knowledge, curricular resources, knowledge of content, knowledge of students, and pedagogical knowledge.

Emma's orientations. Emma's orientations toward the curriculum materials she planned with were positive overall. By positive I mean that she liked most aspects of her departmental materials and did not feel that she needed to change things within the materials. Particularly she indicated that she liked how the department materials scaffold the content and used definitions that were easy for students to understand. One aspect she did not like about these materials was the focus on algebraic rules of transformations that were included, but she ended up keeping all the aspects of the materials, including the parts that focused on the algebraic rules. She was also familiar with and had positive orientations towards the *UCSMP* materials and gave examples of topics that she liked: the function notation of transformations, the definitions of the transformations, and using reflections to build the other transformations and mentioned that she would talk to her department about possibly incorporating these topics the following year. She also mentioned that she knew that the *UCSMP* materials aligned with research on teaching geometric transformations due to the fact she analyzed how textbooks aligned with research on geometric transformations as an undergraduate student. She did indicate that some of the topics such as vectors and the definitions of topics like glide reflections and isometries were too complicated for her students. Ultimately, Emma chose to follow the department materials over the *UCSMP* materials not because she liked them more, rather because it was expected of her by her department to use these materials.

Emma's *orientations towards teaching* focused a lot on how she was evaluated as a teacher. In most cases when she justified her decisions as a teacher she did not focus on the learning of students, but rather on meeting the expectation of others. For example, in her translations lesson she stated,

> I have to do my SLO [Student Learning Objective] evaluation, because I'm a first year teacher. ... I don't have any data to compare last year to this year to. So that's why I have a pre-assessment. To show that my students are learning the material that's outlined in the curriculum.

This excerpt indicates that she included the pre-assessment for her students more to prove that she is doing something rather than to aid students in learning. Emma indicated that the reason she used the department materials and taught some content that she does not ultimately agree with was because the department expected her to and because the content in these materials would be the content that would show up on end of year assessment, an assessment that she is evaluated on based on student scores.

Emma's *orientation towards student learning* was focused on gradually introducing and showing students how to do problems. She believed it was important for students to have tasks that are scaffolded, in other words she wanted students to start with easier problems and work towards harder problems. This was also evident in her decisions to give several examples before letting the students attempt problems. For example, in her composition of transformations lesson she planned to model how to do seven problems on the student worksheet that only included ten problems. She also discussed that students learn better when a topic is taught multiple times and when students have adequate time to allow the material to sink in.

Emma's Goals. With regards to Emma's orientations and the decisions she made I inferred that she has two main goals for the geometric transformations unit. The first and primary goal was to teach the content of her department materials. This inference stems from Emma's orientations to teach in a manner that meets the expectations of others and the fact that she follows the curriculum materials completely even when she does not agree with some aspects of the materials. Her second main goal, which I believe comes secondary to her first was to teach content that she either finds interesting or important but only when she can relate the content directly to her department curriculum materials. This comes from the fact that most of her adaptations involved insertions on specific aspects of her curriculum materials and her orientations to teach things that interest her or are important.

Along with the inferred goals Emma had five stated mathematical goals for her first lesson and six stated mathematical goals for her second lesson. All of these mathematical goals seemed to fit into three main types of categories: a) Goals for students to be able to perform transformations algebraically such as her goal "When presented with two congruent figures, students will be able to list a series of transformations that would produce the image from the pre-image"; b) Goals for students to do things Emma found interesting such as "students will verify that two reflections over intersecting lines result in a rotation"; and c) Goals for students to know the properties of transformations such as "Students will verify that a translated polygon will be congruent to the pre-image." Figure 4 shows how I inferred Emma's mathematical goals aligned with her plans for teaching the lesson. As can be seen in the figure two arrows are pointing from what gets taught to her mathematical goals. This indicates that I inferred that Emma chose her goals based on what she had already planned on teaching rather than the other way around. Thicker borders of boxes indicate that the goal or decision was more prominent than thinner borders. It seems fairly obvious that her goal to teach transformations algebraically comes from the department curriculum materials and not from herself. She indicated that she does not believe teaching the algebraic rule is important, but does so because she was expected to follow the materials. I also inferred that Emma's goal to teach things she found interesting comes from the department materials and not self-created because these type of goals show up in her lessons as an *extension* adaptations that are linked to a particular problem or problems in her curriculum materials. For example, her goal "Students will analyze their compositions and look for efficiency" only relates to one problem in her materials on composition of transformations and seems likely that Emma chose this goal only after reviewing this particular problem. On the other hand, Emma's mathematical goal for students to know the properties of transformations seems to come from herself and not from her departmental curriculum materials. I believe this due to the fact that Emma indicated that the curriculum materials did not promote this idea, but based on her experience felt it was important for students to learn. Likewise, it seemed that there were no particular problems in her department materials that focused on the properties given that all of them in her transformation lessons asked for algebraic rules on the coordinate plane

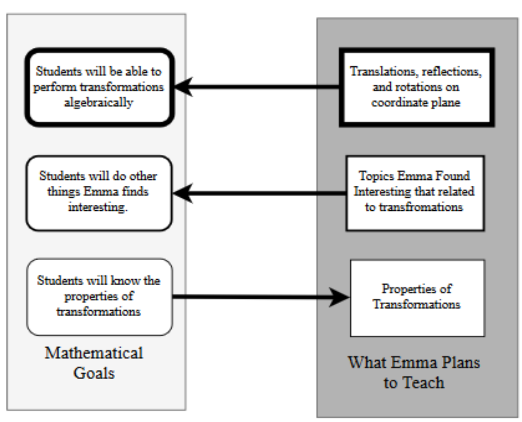

Figure 4. Alignment between Emma's mathematical goals and her lesson plans.

Emma's Resources. Emma made few references to her curricular knowledge or how the content she was teaching connected to content in the future, such as building ideas of congruence and similarity or how the content was connected to previously taught content. The most relevant example of curricular knowledge that Emma gave was in discussing her goals for the translations lesson. She stated, "These goals are most consistent with the Common Core State Standards, and [I] hate to even admit this, but these goals are what they are going to be assessed on. . . These goals are what they are going to be called later in ninth grade." This indicates that she had some knowledge of how the content related to the CCSSM (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010), the end of year assessment, and to the content students will learn in the future, but she did not expound on this knowledge much more than what is in the quotation. Emma also seemed to be aware of the content contained in both her department materials and the *UCSMP* materials. When I asked her questions about the materials, she was readily able to cite examples from both materials. For example, when I asked her about what she liked about the *UCSMP* materials she discussed the idea of building all transformations from reflections, function notation of geometric transformations, and using vectors to describe translations. She also had the CCSSM (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010) in her lesson plan for her translation lesson as well and mentioned that she had been looking up the standards more and more as she realized that her department materials did not always align with the standards. Although Emma mentioned that the goals she planned for will address content her students will use in ninth grade, she gave no clear indication of what this content was nor which particular goals will be most helpful for students in the future.

With regards to *curriculum materials*, Emma had access to the *UCSMP* materials, her department materials, a mathematics textbook adopted by the district, and the Common Core Standards. She primarily used her department curriculum materials to make decisions about what content to teach and choose to *follow* every problem in her department curriculum materials and most of her discussions she inserted were based off problems in her department materials. She did however seem influenced by the *UCSMP* materials because she added a discussion about how two reflections over intersecting lines was equivalent to a single rotation when a composition of two reflections was given in her curriculum materials. Her goals in her first lesson to analyze corresponding side lengths, angle measures, and parallel line properties in transformations might also have been influenced by the *CCSSM* (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010) given that she included standard 8.G.A.1 in her lesson plan that discussed side lengths, angle measures, and parallel line properties.

Emma had several opportunities to build her *content knowledge* about geometric transformations and does have basic knowledge of geometric transformations, but I inferred that she lacked an understanding about which aspects were important when teaching geometric transformations. She recently had taken courses as an undergraduate student discussing many of the ideas involved with geometric transformations prior to her first year of teaching. She also worked as a research assistant analyzing new middle school textbook specifically about geometric transformations. She was familiar with the different properties of transformations and was aware of glide reflection; however, she did not seem to understand how or why teaching glide reflections or isometries was important for students. Emma also did not seem to know why the properties of transformations were important for students to learn. While she did teach her students about properties of corresponding side lengths and angle measures of pre-image and images are the same measures, she did not discuss how she would connect these ideas to congruence. Although when discussing past instruction, she said that students had been introduced to congruence and defined it as side lengths and angle measures being the same. Another indication of Emma's lack of knowledge of the importance of the properties of geometric transformations was that Emma purposely avoided teaching orientations, an important property of transformations, although she did discuss orientations when her students brought up the idea during class.

Emma generally did not discuss her *knowledge of students*, or how students were going to think about the content she was planning. Most often when she mentioned students, it was about what content she thought the students could not do. For example, she discussed that she did not think her students would be able to understand translations in terms of vectors. She stated, "My kids don't really know how to construct angles . . . I feel that this would be a little bit difficult to get precision with that. Intuitively it makes great sense . . . I'm just trying to … figure out how [to] have students get precision if that vector is the only information they have." She also mentioned that her students would not see a reason for learning glide reflections when they were already learning composition of transformations.

With regards to *pedagogical content knowledge*, Emma struggled with how to present geometric transformations to students. She mentioned that she did not know what made a good pre-assessment, and that she would not know how to apply vectors to a classroom setting, and did not know how to cover other ideas she found interesting.

There were a few other resources that influenced Emma's decisions in planning for geometric transformations. School resources (i.e., department materials, expectations from administrators and other teachers or school personnel that could provide resources or advice) were very influential for Emma. She indicated that there was an expectation to use the department materials and that if she wanted to make any major changes she had to wait to discuss it in the summer when all the teachers would review the department materials. Emma made reference to the end of year assessment in her reasoning as well and may have had pressure from the principal, department chair, or other teachers to perform well on the end of year assessment. Emma also indicated that her experiences with mathematics influenced her decisions. For example, she chose to teach about the properties of translations because in her experience the properties were more important than the algebraic rules for translations.

Emma's decision-making process. Although Schoenfeld described orientations, goals, and resources as interrelated in a person decision-making process, he also described that these reasonings can be viewed in a linear progression. Figure 5 shows my inference of Emma's decision-making process in choosing what to teach for her translation and composition of transformation lessons in the geometric transformations unit based on a linear progression which I will call her decision-making process. Note, due to the large number of potential resources and orientations that influenced Emma's goals I chose to include the reasonings I thought were most influential in Emma's decision-making process. The diagram moves from left to right indicating how Emma's orientations influenced her goals which were guided by her resources (the square boxes) that influenced her decisions. I chose not to include any potential resources influencing goals given that the most influential resources in choosing what goals to meet were the same as the resources that aided Emma in carrying out her decisions. The dashed line indicates that the factor was not as influential as a solid line. A thick box indicates a decision that was a major focus in the lesson plan in comparison with the other decisions.

Emma had the goal of teaching the content in her department materials, which was influenced by two orientations: her orientations towards learning and towards teaching in a manner that led to positive evaluations. Given that orientations towards learning has a dashed line, this orientation had less influence than the orientation for positive teacher evaluations. In accomplishing her goal to teach her department materials she used two resources: her department materials and her school context. This whole process led Emma to teach geometric transformations on a coordinate plane. The other path of this diagram begins with orientations towards teaching with a focus on teaching topics that are interesting or important to Emma. This led to the goal of teaching topics that are interesting or important which breaks into two paths. One that leads to the decision to teach the properties of geometric transformations that is based on Emma's resources of undergraduate coursework, the *CCSSM* (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010), and her department materials. The other path led to her decision about the topics she found interesting that relies on Emma's resources: content knowledge, department materials, and the *UCSMP* materials.

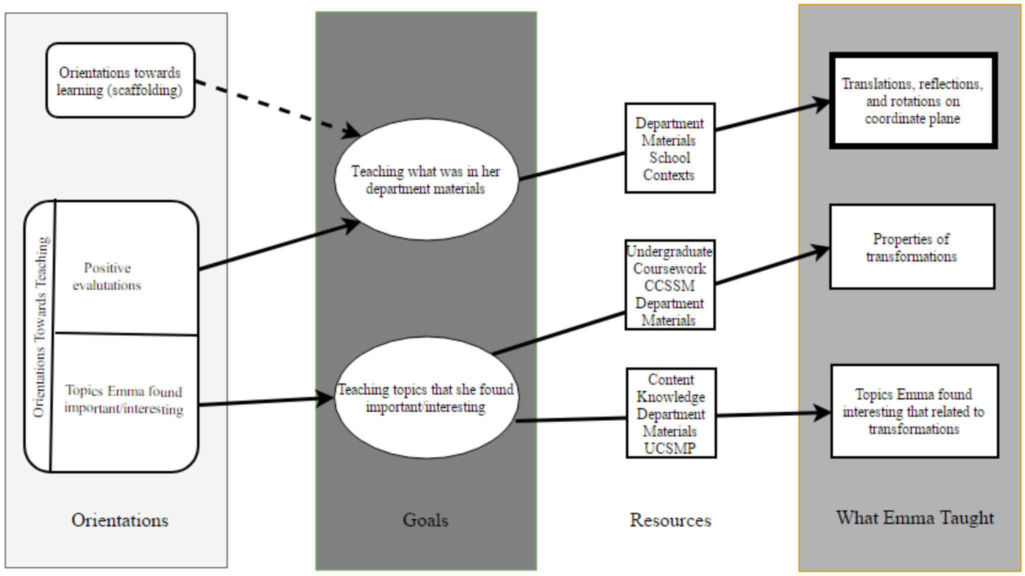

Figure 5. Emma's decision-making process.

Bridget

At the time of the study, Bridget was in her second year of teaching at a public junior high. She taught grade 8 mathematics, both honors and regular students. With regards to designing instruction, her department developed a sequencing of topics to be covered, but did not designate how to implement this sequencing of topics. She collaborated often with fellow teachers and shared many activities with them. Bridget received an undergraduate degree in mathematics education at BYU and took courses that discussed strategies for teaching geometric transformations. Before she completed her undergraduate degree, Bridget worked in a nuclear weapons lab and also completed science and engineering courses during her undergraduate program.

Bridget's general curriculum use decisions. Although Bridget made curriculum use decisions in each of the categories, she most often made curriculum use decision to *follow* her materials. She used two primary materials to plan her lessons on geometric transformations, a website called mathbits.com (Roberts & Roberts, 2017) that contained files for a dynamic geometry software called Geometer Sketchpad (Key Curriculum Press, 2001) and a fellow teacher's materials. Bridget planned to completely follow the worksheet she found online (i.e., use every aspect of the worksheet as is) and only made slight changes to the worksheet her peer teacher gave her.

Although she did some reordering of problems, most of the *adapt* decisions that Bridget made were extra discussions. She added a discussion in the reflection lesson to have students discuss what they learned during the task as a way to close the lesson. In her rotation lesson she inserted several discussions that were not part of the materials her fellow teacher developed. The different discussions she included were: (a) how students can rotate their paper to better visualize a rotation, (b) how 90-degree rotations and 180-rotations relate to each other, (c) the difference between rotating a figure counter-clockwise versus clockwise, (d) what 270-degree rotations are and how to perform them, and (e) a discussion about pre-images and images. Besides inserting discussions Bridget also inserted an activity. After students completed the rotation worksheet and had discussed 270-degree rotations Bridget planned to have them do problems on the whiteboard that required a 270-degree rotation. Bridget also made one change that was not adding to the materials. On the rotation worksheet she switched two of the problems so that students would start with a 90-degree rotation and then do a 180-degree rotation instead of vice-versa.

Bridget did not make a single *omission* to any of the curriculum materials that she decided to use as part of her lesson, but omitted other curriculum materials that were available to her completely. Specifically, she omitted the *UCSMP* materials and her district adopted textbook. Bridget did not make any omission to the specific problems in her materials or to any of the wording, figures, or diagrams in the materials she used.

Bridget made some decisions to *self-create,* specifically she *self-created* her goals. The curriculum materials Bridget used did not contain any goals, which indicated that many of her goals were based on her own experiences in learning mathematics and in thinking about the ways other teachers have taught.

Bridget's decisions regarding geometric transformations. Bridget sequenced her lessons according to a map she and her team developed in the summer. She sequenced her lessons in the following order: (a) translations (b) reflections, (c) rotations, and (d) dilations. Bridget spent one day on each of these topics.

Reflection lesson. In teaching her students about reflections, Bridget used a task she obtained from a mathbits.com (Roberts & Roberts, 2017). The task required students to use a dynamic geometry software program, Geometer's Sketchpad (GSP) (Key Curriculum Press, 2001), to reflect shapes and describe the rules for the transformations as well as notice relationships between the image and pre-image. Initially students reflect a shape across different lines of reflection. These lines of reflection included the x-axis, y-axis, $y = x,$ and $y = -x$. For each reflection over the different lines of reflection students were asked to come up with a hypothesis about what was happening to the coordinates points in the figure. After coming up with a hypothesis, students tested their hypothesis by clicking and dragging some of the points on the original shapes to see if their hypothesis held. If it did hold true, then students were to formalize their hypothesis. After testing reflections over the four lines of reflection and creating a generalized rule students were then asked to measure the side lengths of the pre-image and image and notice if any were the same measure. Bridget thought that the task also included having students notice patterns about the distance from the points in the pre-image and image to the line of reflection, but it did not. Once she noticed that the task did not include this she made no modifications to the task or her lesson plan.

Rotation lesson. In teaching rotation Bridget had her students take notes and then completed some problems on their own. The first part of the notes had students focus on the properties of rotations that were preserved. Bridget's notion of the properties was the size and shape of the figure, because this is what she wanted the students to write in their notes. The notes then had students do a few problems, a counterclockwise 90-degree rotations, a clockwise 90-degree rotation, and a 180-degree rotation (all of these problems had a pre-image on a coordinate graph and students were to rotate the figure about the origin). For this lesson Bridget wanted to bring up the ideas of turning your paper to visualize the rotation and remind them of the difference between the image and pre-image. She also mentioned that it did not matter for a 180-degree rotation which way students rotated the pre-image because students would get the same image. After this discussion, Bridget had five more problems planned; however, these problems gave students the pre-image and image of a rotated figure and asked students to come up with a rule for how the figures were rotated. The last problem had students determine if they rotated an object 73-degrees clockwise would they get the same result rotating it 73-degrees counterclockwise. If there was time at the end of class, Bridget planned to have students work on practice problems on coordinate planes with whiteboards.

Bridget's reasoning for curriculum use decisions. In this section I describe my inferences of Bridget's goals, orientations, and resources that relate to her decisions. With regards to orientations, I specifically focus on Bridget's orientations towards curriculum, teaching, learning, and mathematics. In describing goals, I focus on her inferred goals and stated mathematical goals. In discussing her resources, I focus on her curricular knowledge, curricular resources, knowledge of content, knowledge of students, and pedagogical knowledge.

Bridget's orientations. Bridget's *orientation towards curriculum materials* seems to be based on how well the curriculum materials aligned with what she wanted to teach. She mentioned "that she doesn't have a very good textbook" and this is why she did not use it. She indicated that the reason she thought the textbook was not good was related to the alignment with the *Utah Core Standards* (Utah State Board of Education, 2010). When discussing the *UCSMP* materials in her reflections lesson she said, "it talks about things we don't cover, we don't talk about reflecting over parallel lines or things like that, so it wasn't very useful." In other words, the *UCSMP* materials did not cover the kinds of things (e.g., transformation on coordinate planes) she wanted to teach. In discussing the other curriculum materials she used (i.e., the website (mathbits.com (Roberts & Roberts, 2017)) worksheet and the worksheet provided by a fellow teacher) she mentioned that she chose to use these because they had the content she wanted to teach. With regards to materials she would like to have she says, "I wish we had materials that had problems, because we don't have anything like that."

It seems that Bridget's *orientation towards student learning and teaching* mathematics was connected to her beliefs that her job as a teacher was to provide opportunities for students to get real experiences with mathematics and that she needed to give them these opportunities. In her reflection lesson interview she stated, "I just want them to get involved and have some hands on knowledge" and indicated that the reason she used Geometer Sketchpad was for students to "actually do it and see what is happening." She mentioned that she wanted to give her students opportunities to do mathematics that related to the real world. For instance, when discussing her plans for teaching rotations she indicated that performing a rotation was more important than identifying rotations and said, “It is important for them to identify that is what is going to be on the Sage [year-end assessment], but it also is important for them to perform it, because if they are going to do anything in the real world like animation or architecture they’re going to know how to actually move it.” She also mentioned that some teachers gave assignments that limit the ways students can do the mathematics and she tried to avoid these situations. Another orientation Bridget has is that students should focus solely on the mathematics. This is why Bridget used the GSP (Key Curriculum Press, 2001) program that had the reflection tool built in rather than constructing their own, she did not want students to worry about learning the software, which could have gotten in the way of the mathematics. Bridget also seemed to have the orientation that an important aspect of teaching is to cover content. This was apparent by the fact that she was satisfied with materials when they “basically covered what I wanted” and by the fact that she did not adapt curriculum materials to align with her mathematical goals. It was also clear that Bridget believes part of students’ experience with mathematics is to practice problems. The majority of Bridget’s rotation worksheet was practice problems with the exception of one question that had students think about the properties. As mentioned earlier, Bridget also wished she had more access to practice problems for her students to work through.

Bridget’s goals. I inferred two goals with regards to Bridget’s decision-making process. Her primary goal seemed to be what I would consider covering content. I believe that this was her primary focus because while she had orientations to do other things such as teach for discovery and application, she seemed to settle for lesson plans that were not focused on discovery and application, but did relate to the things she wanted to teach. Another reason I inferred this was her main goal was because of the inconsistencies in her mathematical goals between lessons and in the instruction she planned for. Bridget’s secondary goal was to teach for discovery and application. Bridget indicated several times that she wanted students to discover the mathematics and to use it in a manner that would benefit them in real life. Most of her lessons were not readily applicable to real life. Although she did indicate that she focused on students performing rotations because this would help them apply it to real world situations.

Bridget had one mathematical goal for each of her lessons and each of these goals consisted of two parts. For her reflection lesson Bridget had the goal: “I want them to discover that reflections preserve distance between points, and the distance between points and the line of reflection.” The first aspect of this goal was a focus of the student task in the last question on the mathbits.com worksheet (Roberts & Roberts, 2017). Students measured corresponding side lengths in an image and pre-image and compare them. Bridget indicated that she thought the worksheet asked students about the property of preserving distance between points of a figure and the line of reflection, but realized it did not. She did not make any adaptations to make the task align with this property when she realized the worksheet did not include it. The majority of the worksheet guided students to create a coordinate rule for reflecting images, yet there was nothing in Bridget’s goal that focused on the coordinate rule. For her rotation lesson, Bridget had the goal for students to recognize when a rotation has taken place, but also to create an image from a pre-image using a rotation. She also indicated that she thought the ability to perform a rotation was more important than recognizing one. Her rotation lesson did not align at all with her mathematical goal of recognizing rotations given that there were no problems or questions that required students to recognize or distinguish rotations from other transformations. Her lesson did seem to align with the second goal. The problems on the worksheet had students perform rotations and write a rule for rotating the pre-image. One aspect that was included on the student worksheet, but not in her goals, was that the worksheet had students list two properties that were preserved with rotations. On the answer key of the worksheet it indicates that the two properties were size and shape.

In analyzing her goals it is interesting to note that the goals for the two lessons seem inconsistent. In the reflection lesson the goal focused more on addressing properties of reflections while her goal in the rotation lesson ignored properties and focused on recognizing and performing rotations. Bridget seems to have inconsistencies with her goals and what she planned to teach. Figure 6 shows the relationship between the main ideas in Bridget's mathematical goals and what actually gets taught. In looking at the figure a dashed line indicates that the mathematical goal was partially addressed in what was taught and no line indicates the goal was not addressed in what was taught. It is unclear whether the idea of performing transformations stemmed from the materials she was using or whether it came from herself. Bridget indicated that the materials she used covered basically what she wanted to cover, but she did not mention what she wanted to cover and given the inconstancy of her goals it was difficult to infer. Bridget's goal of discovering properties did seem to come from her rather than the materials she used. I made this inference given that Bridget stated she looked for curriculum materials that were similar to those she had used in past experiences and focused on the properties of reflections. She also seemed surprised when she realized the materials did not align with the goals she had as well as she thought. Her goal of recognizing transformations did not relate to anything in her lesson plan. Bridget did indicate that this goal was not as important to her as performing transformations.

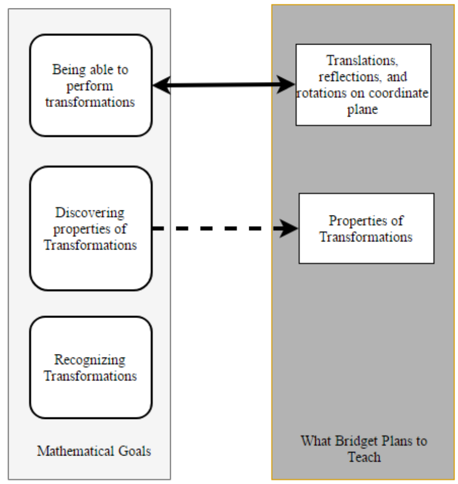

Figure 6. Alignment between Bridget's mathematical goals and her lesson plans.

Bridget's resources. *Bridget's curricular knowledge* was good in some aspects and lacking in others. She drew on a variety of resources. She was in contact with several other teachers, both in her department and at other schools, and often shared and gathered resources from them. For example, when designing her rotation lesson she talked to her friend who had already designed a worksheet. Bridget said, "it was basically what I wanted, so I changed her's a little bit." Bridget also drew on her experiences from her undergraduate program in mathematics education. She indicated that using GSP (Key Curriculum Press, 2001) to investigate the properties of reflections was inspired by an activity she did as an undergraduate. Bridget also used the internet to find resources to use, given that her first lesson was based on materials found on a website (mathbits.com (Roberts & Roberts, 2017)). Bridget made little reference to what students had learned in the past or what they will be learning in the future.

Bridget had a number of curriculum materials available to her. She had the *UCSMP* materials, her district adopted textbook, other teachers, her past experience, and the internet. Bridget does mention that she wished she had more access to computers and computer programs such as GSP (Key Curriculum Press, 2001) and would use them more often if they were more readily available.

Bridget seemed to have fairly proficient *content knowledge* with regards to geometric transformations. She seemed to know most of the properties of geometric transformations; although, the *UCSMP* textbook reminded her of some that she had forgotten, such as orientation. She also seemed to know why the ideas of orientations and isometries were important, yet she did not explicitly plan to teach these ideas.

With regards to *knowledge of students*, Bridget seemed to think somewhat about how students were going to react to materials. For example, she decided to use a GSP (Key Curriculum Press, 2001) file that included pre-made shapes and buttons that would transform the shapes rather than having students construct shapes from scratch and figure out how to do the transformations. She did this in order for students to focus on the mathematics rather than on learning the intricacies of the software. For most other aspects she talked in terms of what she was going to do rather than how her students were going to react to her instruction. An example of this occurred in her rotation lesson when she indicated that she was going to have her students physically turn their paper when doing rotations. In this example Bridget indicated that she made this decision because it was a technique she had seen before and liked it rather than it being something that would cause the students to think a certain or even to help them understand rotations.

With regards to other resources Bridget indicated that she wished she had more access to technology. Specifically she wanted a classroom set of computers that had geometry software such as Geogebra. She indicated that if she did, she could do more inquiry-based lessons using the technology.

Bridget's decision-making process. Figure 7 shows my interpretation of Bridget's decision-making process and should be read in a similar manner to Figure 5. Some aspects unique to Bridget's inferred decision-making process is the fact that one of the goals seems to be a lot more influential than others. Bridget's lessons seem to focus more on covering transformations on coordinate planes rather than the properties of transformations or even discovery lessons. Although Bridget indicated things like using GSP (Key Curriculum Press, 2001) and performing rotations were part of her discovery/application beliefs. Another unique aspect of her process is the fact that the internet and technology were contributing resources.

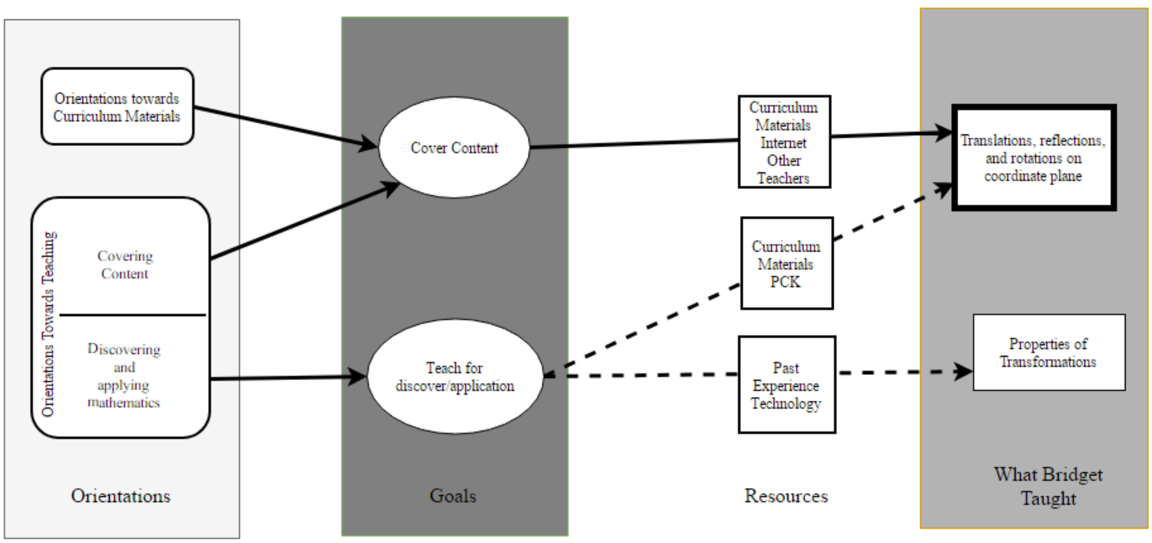

Figure 7. Bridget's decision-making process.

Kelsey

When this study was conducted, Kelsey was in her tenth year of teaching at a junior high school in a large school district. She taught mathematics to grades 7 and 9 students as well as grade 7 honor students. In her district the honors grade 7 standards include geometric transformations standards from grade 8, which made her eligible for this study. Kelsey used the mathematics textbooks selected by her district, but also had freedom to choose her content and how to teach. She often sought tasks online, from conferences, or created them herself. She attended two different universities for her undergraduate and graduate degrees, both of which were in mathematics education. Her course work did not address geometric transformations directly, but she had experience from teaching the content the previous year. Kelsey also had experience in mathematics education leadership. She had served as the department head for her mathematics department for several years, and also held leadership positions in the state mathematics teacher organization.

Kelsey's general curriculum use decisions. Kelsey also made decisions in each of the curriculum use categories. Most of Kelsey's decisions to *follow* involved using specific problems for students' homework assignments. These homework problems were from the *Utah Middle School Mathematics* (University of Utah, 2013) textbook (www.utahmiddleschoolsmath.org) and consisted of problems that require students to answer a variety of questions about transformations (e.g., draw transformed shapes, identify coordinate rules for specific transformations, find slopes of line segments in shapes, and describe different patterns or properties). Kelsey followed six of seven problems from the translation homework materials and five of eight problems from the reflection homework

Kelsey overall made more decisions to *adapt* than to *follow*. She did make adaptions to all the materials she used, but the majority of her adaptions were to the *Utah Middle School Mathematics* (University of Utah, 2013) materials, most specifically the rotation lesson where she changed every homework problem only keeping specific aspects of certain parts. An example of this can be seen in Figure 8. The same pre-image was used and both the original and the adapted problem asked students to rotate the figure 180-degrees. But the center of rotation was changed and the questions about the rotation were changed as well.

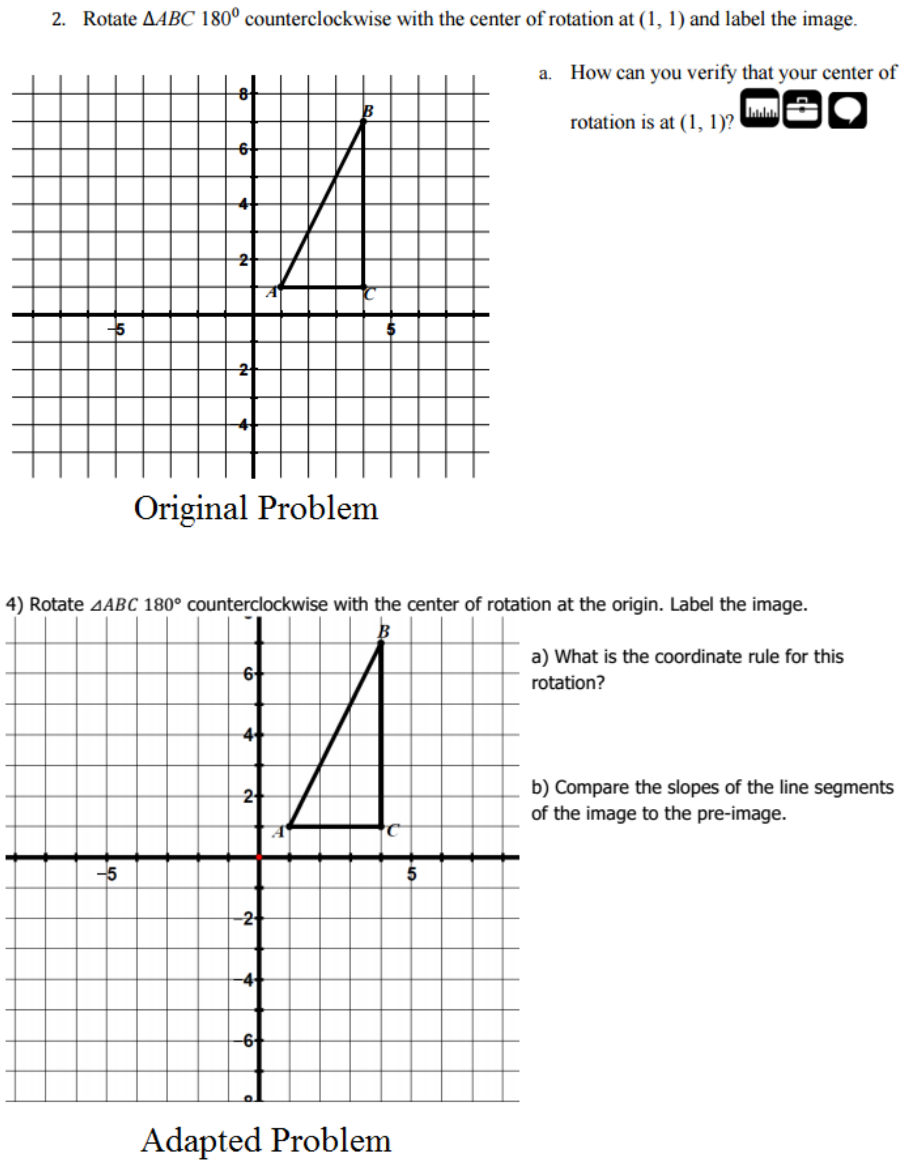

Figure 8. Comparison of homework problem from *Utah Middle School Mathematics* (University of Utah, 2013) textbook and Kelsey's adapted problem.

Most of Kelsey's adaptions involved inserting content. For example, on the reflection lesson she added an extra homework problem, which required students to decide whether reflections had the same properties of translations. Another example is on the rotation homework she inserted two questions: one that required students to write a coordinate rule and another that required students to write the new coordinates of a rotation going in the opposite direction (i.e., counterclockwise).

She also made adaptions by changing the meaning of problems, which happened most often in the rotation homework. On several of the original problems, students were asked to do rotations around centers of rotation that were not the origin and then confirm where the centers were as can be seen in Figure 8. Kelsey changed these problems to all have a center of rotation at the origin and asked students to find coordinate rules and slopes of the lines instead of confirming the center of rotation. Kelsey also included adaptions where she reworded problems and reordered problems.

Kelsey *omitted* entire curricula and specific problems in certain curriculum materials. She ended up omitting the *UCSMP* materials and her district adopted textbook materials entirely. She also ended up omitting several of the problems in the *Utah Middle School Mathematics* (University of Utah, 2013) materials. The problems she omitted were similar to those she kept. By similar I mean they asked the same questions just with different images and likely did so to reduce the number of homework problems the students had to do.

The majority of Kelsey's decisions were *self-create* decisions. With exception to her introductory lesson, Kelsey designed all the tasks she used herself as well as the discussion questions to go along with the tasks. Kelsey also created her own goals and did not pull them from the materials she was using.

Kelsey's decisions regarding geometric transformations. Kelsey sequenced her lessons in the following order: (a) introduction to geometric transformations, (b) translations, (c) reflections, (d) rotations, and (e) composition of transformations. Kelsey spent one day on each of these topics. She claimed that translations were easier for students than reflections and reflections were easier for students than rotations and therefore, sequenced those lessons from easiest to hardest. I discuss four of the lessons (i.e., introduction to transformations, translations, reflections, and rotations) that I gathered data about Kelsey's lesson plans.

Introduction to geometric translations. Kelsey's first lesson involved students manipulating different shapes and writing instructions for others to manipulate the shapes in the same manner. Specifically, Kelsey gave students cutouts of different types of pentaminos as well as pictures showing how a pentamino could be transformed. Students were then expected to move their cutout shape (i.e., pentamino) from one of the images to the other and write instructions for how to do this. Partners were then required to follow the directions and only the directions given them and see if the shape ended up on the new image. Kelsey planned to discuss what students learned and which instructions were most helpful in manipulating the shapes.

Translation lesson. In teaching translations, Kelsey had students work with partners through a self-created task that revolved around moving blocks in a park that was split into four quadrants. On the worksheet associated with the task the first few questions had students move blocks a specific distance in one direction (i.e., up, down, left, or right). The second set of questions had students move blocks an arbitrary distance in one direction. The third set of questions had students move the blocks either left or right in an arbitrary distance and then move the blocks up and down an arbitrary distance. The last question had students create a rule for moving the blocks in two directions with two arbitrary distances. She then held a discussion about the task (questions for this task were self-created) and asked students to present their findings and come to an agreement about a rule they could use to always translate an image in the same way. After the discussion she planned to have students work through examples she gave them using the coordinate rule. She also gave students a homework assignment from the *Utah Middle School Mathematics* (University of Utah, 2013) materials to work on in class. Of the seven homework problems that students were assigned, only two had students use a coordinate rule to draw a translated figure or come up with a rule for translating a figure. The other five questions had students find slopes and side lengths of the corresponding sides of translated figures which was content that was never planned for in Kelsey's lesson plan.

Reflection lesson. Kelsey's self-created reflection task was similar to her translation task. Students worked with partners and reflected blocks into different quadrants. The first problem had students reflect from quadrant 2 to quadrant 1, the second problem had students reflect from quadrant 1 to quadrant 4, the third problem had students reflect from quadrant 2 to quadrant 1, and she gave a bonus problem for students to reflect the blocks from quadrants 1 to 3. After doing the problems she wanted students to create a coordinate rule for reflecting over the x- and y-axis. She planned to discuss the rules that students came up with as a whole class. After solidifying the coordinate rules for reflections, she planned to discuss the properties of congruent figures; specifically, that parallel lines stay parallel in congruent figures and that corresponding sides and angles have the same measures in pre-images and images. After this she planned to have students work on their homework assignment from the *Utah Middle School Mathematics* (University of Utah, 2013) materials which were mostly adapted for this lesson. The first six problems had students write a coordinate rule to represent a given transformation for each problem, where a pre-image and image are shown on a coordinate plane. An interesting fact about the reflection homework was that students were asked to write the equations of lines of reflection for oblique lines, a topic that was not planned for in her lesson plan. One original problem asks students to reflect an image over the line $y = x$. Another problem displays two images reflected over different lines of reflections (e.g., $x = 1$, $x = 4$, $y = -x$, x-axis) and asks the students to find not only the coordinate rule, but the equation of the line of reflection. On one problem students were to reflect an image over the line $y = 3x - 1$. The last problem also asks students about several of the properties of reflections in comparison to the properties of translations as can be seen in Figure 9.

Properties of Translations	Also true for Reflections? Yes or No
Segments connecting the corresponding vertices of the image and pre-image are the same length.	
Segments connecting the corresponding vertices of the image and pre-image are parallel to each other.	
Corresponding segments in the image and pre-image are the same length.	
Corresponding angles in the image and pre-image have the same measure.	
Parallel lines in the pre-image remain parallel lines in the image.	
Corresponding segments in the image and pre-image have the same slope.	

Figure 9. Homework example from Kelsey's reflection lesson.

Rotation lesson. Kelsey's rotation lesson was similar to her translation and reflection lessons. She gave students a task she *self-created* which gave the context of a park where bricks need to be rotated into different quadrants. For all of the problems on this task students were only asked to do rotations in increments of 90-degrees. As with the other tasks, students were to create a coordinate rule. Kelsey planned to discuss what students had learned and solidify a rule. On the homework assignment that Kelsey adapted, students were given a pre-image and image of figures that were rotated and asked two of three different questions: what is the angle of rotation, what is the coordinate rule for the rotation, and how do the slopes compare between the image and pre-image? Although Kelsey prepared students to find angles of rotation (at least the 90-degree, 180-degree, and 270-degree rotations that were in the materials) and the coordinate rule for the rotation, she did not discuss finding or comparing slopes at all in her lesson plan. Although, finding slopes may have been a topic covered earlier in the year.

Kelsey's reasoning for curriculum use decisions. I now describe Kelsey's reasoning for her decisions based on my inferences with regards to Kelsey's orientations, goals, and resources. With regards to orientations, I specifically focus on Kelsey's orientations towards curriculum, teaching, learning, and mathematics. In discussing her resources, I focus on her curricular knowledge, curricular resources, knowledge of content, knowledge of students, and pedagogical knowledge**.**

Kelsey's orientations. Kelsey had mixed orientations towards curriculum materials, depending on how well the materials aligned to the *Utah Core Standards* (Utah State Board of Education, 2010) and whether the materials had students use a task to discover mathematics. Kelsey stated that when she plans lessons she starts with the different standards of the *Utah Core Standards* (Utah State Board of Education, 2010) and then searches for tasks that will align with these aspects. She also stated that she tries to find tasks "that help [her students] discover [the goals of her lesson]." Her orientation towards tasks is seen in Kelsey's actions and given that she used a task for every lesson in her geometric transformations unit. Kelsey's main argument for not using the *UCSMP* materials was the lack of alignment to the *Utah Core Standards* (Utah State Board of Education, 2010), specifically she argued that the materials were not grade level appropriate. Kelsey also believed that every set of materials needed to be adapted for her particular students. She specifically said with regards to identifying tasks to use for her lesson, "If there is a task, I'll tweak the task, rewrite the task, whatever to make sure that it is meeting her [students] needs."

Kelsey's orientation towards student learning was focused on students discovering and discussing mathematics. This is evident in not only what Kelsey said about wanting her students to discover mathematics, but also by the fact that the majority of her teaching consisted of using tasks designed in a specific way to bring out certain mathematics. Kelsey also spent a lot of time thinking about how her students were going to think about the materials she gave them and if they would be led to where she wanted them to go. She also always planned to hold a debriefing where students presented their finding rather than her giving them material to be remembered.

Kelsey's goals. I inferred that two of Kelsey's main goals in the lessons I interviewed her about were to teach in a manner that aligned with *Utah Core Standards* (Utah State Board of Education, 2010) and to implement task-based learning. As mentioned previously Kelsey indicated that she began all of her planning by reviewing the standards and trying to find tasks that aligned with the standards or to create these tasks herself. When asked about why she used particular examples or designed her materials in certain ways she referenced the standards several times. She also indicated that one of the main reasons she did not use the *UCSMP* materials was because it addressed content that was not grade 8 appropriate which I inferred to mean not aligned with the standards. In many of her reasoning, Kelsey indicated that she believed students learned best through discovery and discussion and seeked to align her materials to this learning style. As can be seen from her decisions every lesson, she used tasks that were aligned to her interpretation of the standards.

Besides her overarching inferred goals, Kelsey had three types of mathematical goals for her lessons: a) To discover coordinate rules for the different geometric transformations such as, "Discover the coordinate rule for rotation, namely a direction and a degree of rotation"; b) For students to know the properties of geometric transformations such as,

> A reflection will change some characteristics of the figure, namely the slope of any line will be the opposite slope. Parallel lines are still parallel. Angles remain the same. The image will be congruent to the pre-image;

and c) For students to know what transformations do or what they look like such as, “A rotation causes a figure to turn about a certain point in either a clockwise or counterclockwise direction a specified measure of degrees.” Kelsey seemed to create her lessons around her mathematical goals, which is not surprising given that she *self-created* most of her tasks. One thing of interest is she did not give the mathematical goals equal space in her lessons as can be seen in Figure 10. Transformations on coordinate planes was discussed far more than the properties of transformations. Kelsey also seemed to include content that was not a part of her goals. Many of the homework problems did not align with what she considered to be content in the *Utah Core Standards* (Utah State Board of Education, 2010) and did not include this content in her goals.

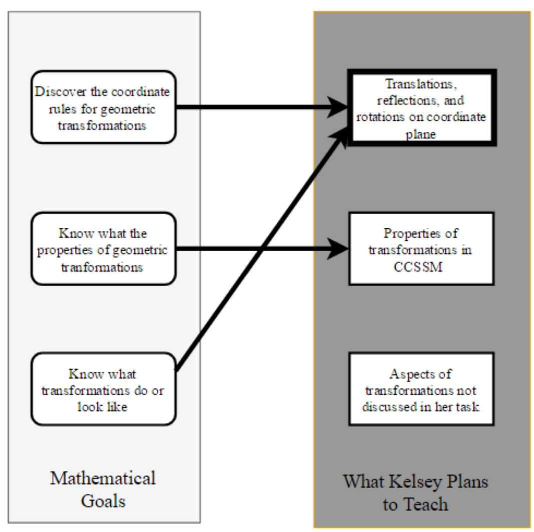

Figure 10. Alignment between Kelsey’s mathematical goals and her lesson plans.

Kelsey’s resources. With regards to curricular knowledge, Kelsey seemed to know of a wide range of materials that were available to use in planning her instruction. She has also gathered a lot of materials from different conferences such as the task she used for her introductory lesson and is familiar with several websites and books that aided her in planning. She indicated that she was familiar with the *Utah Core Standards* (Utah State Board of

Education, 2010) but only referenced the grade 8 standards in her decisions. In fact, her decision to not use the *UCSMP* materials or the district textbook stemmed from them not being aligned to the grade 8 curriculum standards. She does have some false assumptions about the *Utah Core Standards* (Utah State Board of Education, 2010). For example, she thought that the *Utah Core Standards* required students to only work with 90-, 180-, and 270-degree rotations or that the *Utah Core Standards* (Utah State Board of Education, 2010) require students to only rotate figures around the origin. It also seemed that Kelsey may not know what is covered in the homework she assigned students in the geometric transformations unit. The homework covered properties and content that were not discussed in her lessons and did not align with her mathematical goals.

With regards to curriculum materials, Kelsey had access to the *UCSMP* materials, her department materials, a mathematics textbook adopted by the district, her state standards, materials she gathered from professional developments, several websites, and books on teaching strategies. She mainly chose to create her own materials, and supplemented these materials with homework problems from the *Utah Middle School Mathematics* (University of Utah, 2013) materials.

Kelsey seemed to have content knowledge about geometric transformations on a coordinate plane, but lacked knowledge of the importance of the properties of geometric transformations. She emphasized coordinate rules for translations, rotations, and reflections and created tasks for students to discover these rules. She also had students only do reflections along the y-axis, x-axis, $line\ y = x$, and line $y = -x$ and only do rotations about the origin because these were the types of reflections and rotations that can be done on a coordinate plane. She seemed to lack content knowledge on the importance of orientations. For example, on her reflection task she chose shapes that were not symmetric so students could tell which transformation was used, specifically so students would not mix up translations and reflections. If she had taught students about orientations, she would not have had to limit herself to asymmetric shapes, because the orientation of a figure changes for reflections and not for translations.

Kelsey seemed to have adequate knowledge of students and gave a lot of thought to how her students were going to perceive and think about the tasks she gave them. For example, during her introduction to transformations lesson she fully expected students to get frustrated by being limited to the instructions that their peers wrote down, and was prepared for when this happened. Another example comes from her translation lesson when she described how she used certain questions in the student task to get them thinking of a variable in terms of “x+a” instead of just as “x”. She did this by getting them to move pentaminos at first a fixed amount, than at a variable amount, and then anywhere on the “city” or coordinate grid.

It seemed that Kelsey had pedagogical content knowledge for her students to come up with coordinate rules for geometric transformations, but her focus on the coordinate rule limited her approach to certain transformations. Her tasks were designed in a way that led students to understand different aspects necessary to come up with a coordinate rule and she had a debriefing after students worked on a task to solidify the rule if anyone did not find it. But again, all of her tasks focused on the coordinate rules, which restricted her to using asymmetrical shapes, reflections over the x- and y-axis and the line y=x, rotating objects only around the origin, and rotating objects only in increments of 90-, 180-, and 270-degrees.

Kelsey’s decision-making process. Kelsey’s inferred decision-making process is straight forward and can be seen in Figure 11. The role of *Utah Core Standards* influenced her orientations, goals, and resources. One aspect that is unique to Kelsey is that her pedagogical content knowledge (PCK) and knowledge of students also become resources that were influential in her decision-making process. Kelsey was also the only teacher who had a goal that related to a philosophy of how mathematics should be taught, specifically she had the goal to teach using tasks.

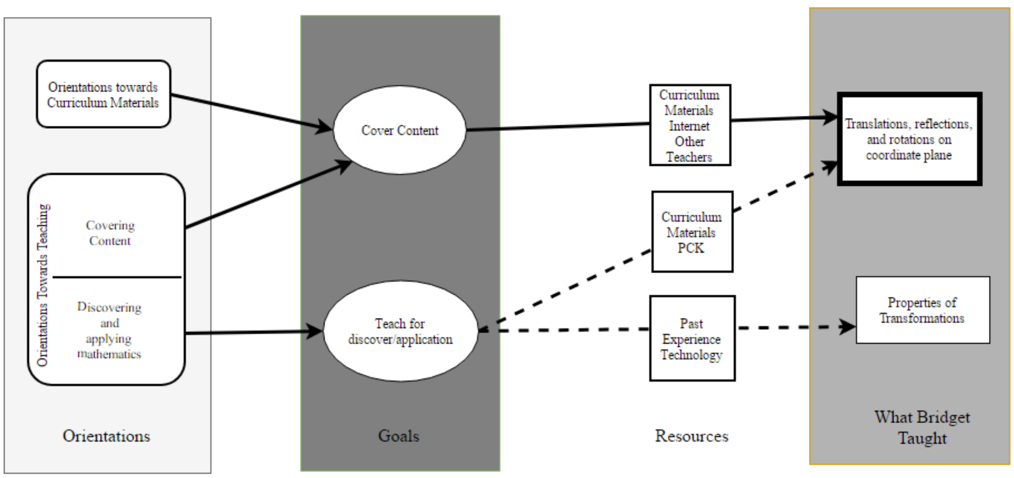

Figure 11. Kelsey's decision-making process.

Summary of Teachers' Decisions and Reasoning

With regards to curriculum use decisions, all three teachers made decisions in each of the curriculum use categories rather than making all of their decisions in just one of the curriculum use category as can be seen in Figure 12. Note that the unit of analysis was based on an instance of a decision or any instance where a teacher made a choice about what was to be included or not included in the lesson plan or materials given to students. Readers should also note that I did not evaluate each decisions, so while the instances may be seen as equal in the figure, some decisions may have been more influential than others. If there were multiple instances of the same decision, only one of these instances was counted. It can also be seen that Kelsey's number of instances is significantly higher than the other two teachers. This is due to the fact that I gathered data and coded four of Kelsey's lesson while only gathering data and coded two of the other two teacher's lessons.

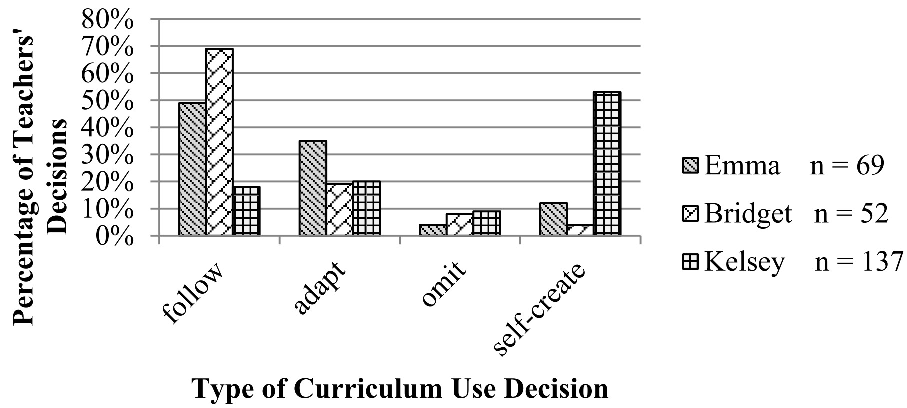

Figure 12. Overview of Teachers' Curricular Decisions in Planning Lessons for Geometric Transformations.

With regards to the *following* category there is a clear difference in the decisions of the novice teachers (Emma and Bridget) compared with the experienced teacher (Kelsey). The majority of decisions for both novice teachers were to follow their curriculum materials. Whereas, Kelsey did some following, but not to the extent that the novice teachers did.

The *adapt* category was the second highest category for all three of the teachers, with Emma adapting the most. In analyzing the adapted instances of the different teachers, there were some major differences in how teachers adapted their materials. In comparing the different adapted instances used by the teachers five categories emerged of different adaptation. These categories were:

- *Changing content* – this type of adaptation changed the mathematical content of a problem or activity. An example of this was when Kelsey changed some of the homework problems on her rotations lessons from doing rotations around non-origin points and confirming where the centers of rotations were to doing rotations around the origin and finding the coordinate rules and slopes of lines.

- *Extending* – this type of adaptation involved teachers following aspects of the curriculum materials, but then adding a discussion or an activity in such a way to extend the mathematical content. An example of this was when Emma including a discussion about how two reflections over intersecting lines could be seen as a rotation as well after students composed two reflections over intersecting lines.
- *Reordering* – this type of adaptation involved teachers reordering problems or activities found in curriculum materials. An example of this was when Bridget reordering the problems in the rotation worksheet switching the problems to address a 90-degree rotation before a 180-degree rotation.
- *Rewording* – this type of adaptation involved teachers rewording or reformatting the curriculum material in some way, but it did not affect the overall meaning or content of the problem. For example, Kelsey made a rewording adaption on one of the problems in her translation homework. The original problem had a part of the question bolded and for her version, Kelsey removed the bold.
- *Other Purpose* – this type of adaption involved using the curriculum materials in a way that it was not designed to be used. An example of this was when Emma used some of the questions on a retake-version of a test as a pre-assessment for her students.

Figure 13 displays the different types of adapted instances made across the three teachers. The most common form of adapting was extending. Over half of the adapting decisions for all three teachers were to extend the content. Emma's expounding generally consisted of adding discussion about the properties of translations or other topics she found interesting. Bridget's expounding mostly had to do with addressing 270-degree rotations, a topic that was not found in her materials. The majority of Kelsey's extensions were on the rotation homework, in which she added her own problems that seemed to address more of what she taught in class. Another item of note in regards to these subcategories for adaption is that that Kelsey, the experienced teacher, was the only teacher to adapt by changing the content.

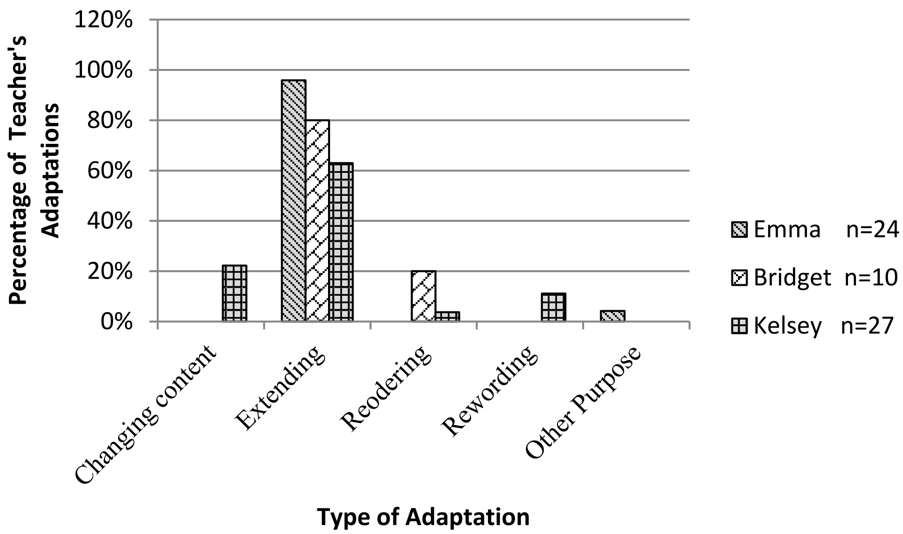

Figure 13. Teachers' adaptations by category.

Omission seemed to be the lowest category of curriculum use decisions made by all three teachers, although they disregarded the *UCSMP* materials and district adopted textbooks entirely. Emma was the only teacher who made any decision to use the *UCSMP* materials, but made only one decision related to the *UCSMP* materials.

All three teachers had decisions to *self-create* as well. The majority of Kelsey's (the experienced teacher) decisions were self-creating while the novice teachers made very few decisions to self-create. Another difference between the novice and experienced teachers was that all of the self-create decisions that the novices made were in terms of their goals; whereas, the majority of the self-create decisions Kelsey made were in creating her own curriculum materials.

Comparison of teacher's decision regarding geometric transformations

Table 4 displays the teachers' decisions for the sequencing of the geometric transformations lessons as well as the sequencing of the lessons in *UCSMP*. All the teachers used different curriculum materials in planning how they sequenced their unit, yet they all tended to sequence them in similar ways. All three teachers taught translations, before reflections, and reflections before rotations, unlike the *UCSMP* materials which sequenced the same topics in the following order: (a) reflections; (b) translations; (c) rotations. Emma and Bridget also taught dilations in their unit, while the *UCSMP* materials discuss dilations in another unit. Besides choosing to order the content and include content different than the *UCSMP* materials, the teachers also taught the geometric transformations concepts in fewer lessons than the *UCSMP* materials.

While *UCSMP* is a high school textbook and has some content such as vectors that may not be appropriate for grade 8 students, there are some advantages in how the geometric transformations unit is organized. *UCSMP* is setting up the idea of congruence. It builds on student intuition about the different transformations and then discusses isometries and congruence, saving topics focused on similarity like dilations for another unit. The *UCSMP* lessons also build on each other which can aid in student learning (Usiskin, 1972). In *UCSMP* translations, rotations, and glide reflections are all built from composing reflections. This not only allows students to understand how each of the transformations are connected to reflections but also how the properties hold true (Usiskin, 1972). For example if angle measure and side lengths are preserved for all reflections then figures that have been repeatedly reflected should also have the same side lengths and angle measure as their pre-image. Likewise if a property is changed with each reflection like orientations, a student could know that orientation is not always preserved for each transformation.

Table 4

Sequencing of Geometric Transformations Unit.

Lesson	Emma	Bridget	Kelsey	*UCSMP* Materials
1	Translations	Translations	Introduction to Transformations	Reflecting Points
2	Reflections	Reflections	Translations	Reflecting Figures
3	Rotations	Rotations	Reflections	Golf/Billiards Application Activity
4	Dilations	Dilations	Rotations	Translations
5	Composition of Transformations	----	Compositions of Transformations	Rotations
6	----	----	----	Translations and Vectors
7	----	----	----	Isometries
8	----	----	----	When are figures congruent?

Translations. Although the teachers used different materials, both Emma and Kelsey sought to accomplish similar goals in teaching translations. Both teachers wanted their students to understand the procedural rule for translating figures on a coordinate plane and both of them wanted students to know the properties of corresponding side lengths, corresponding angles, and corresponding parallel sides would remain the same after a translation. Emma used a worksheet that gave students a procedural rule or “code” for transforming points on a coordinate plane to accomplish these goals, while Kelsey had students work through a task where they discovered the procedural rule. Both teachers also made reference to either the state or national standards when discussing these properties. One main difference in their lesson plans was that Emma brought up the idea of the different properties she was trying to get her students to learn, while Kelsey did not address the properties in her lesson plan.

Reflections. Bridget and Kelsey prepared similar lessons for teaching reflections. Both teachers had tasks where students would do reflections into different quadrants, over the line $y = x,$ and in Bridget's case the line $y = -x$ and had students create a rule to describe the reflection that resulted. An interesting note is that in their lesson plans neither teacher addressed reflections over oblique lines; however, Kelsey had homework problems that involved oblique lines. One difference between the teachers' plans was the different properties they planned to discuss in their reflection lesson. Kelsey planned to discuss when a reflection is done corresponding side lengths, corresponding angle measures, and corresponding parallel sides remain the same. Bridget only planned to discuss the property of corresponding side lengths remaining the same, although she thought that the worksheet she was using included activities about the distance between a pre-image point and image point and the line of reflection remained constant. Neither one of the teachers planned to discuss the orientation of a figure and Kelsey chose asymmetric shapes to avoid difficulties that orientations could have cleared.

Rotations. Bridget and Kelsey had similar lesson plans for teaching rotations as well. Both focused on having students perform rotations about the origin in increments of 90-, 180-, and 270-degrees. Both teachers also only used examples of rotations where the center of rotation was the origin rather than different points. These similarities likely stem from only performing rotations on the coordinate plane. When asked why she only used these types of examples Kelsey indicated that she thought it was in the standards, but later described that she must have chosen them, because they could be done using a coordinate rule. While Bridget gave no indication of why she only chose these types of examples all of her problems were also done on a coordinate plane. Another similarity of both teachers in teaching rotations was that both planned to help students visualize the rotations with some sort of manipulation. Bridget had her students rotate her paper, while Kelsey had her students use patty paper to trace and rotate. This may indicate that rotations may be harder for students to visualize than translations or reflections, or at least may be more difficult in the minds of teachers.

Comparison of geometric transformations lesson overall. For all the teachers, having students learn the rules for performing transformations on a coordinate plane seemed to be the main goal of their lessons. All the teachers limited the cases of what they taught to fit the rules they taught (e.g., non-oblique reflections, rotations about the origin, rotations in increments of 90-degrees). Emma and Kelsey also emphasized the transformation properties listed in the *CCSSM* (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010) and *Utah Core Standards*. Specifically, corresponding side lengths, corresponding angle measures, and corresponding parallel sides would remain the same after a transformation; whereas, properties were not a major focus for Bridget. All three teachers made no specific plans to teach orientations of figures. Emma stated that she did not want to teach orientations just in case it might confuse students. Given that orientation was not mentioned in any of Emma's departmental materials may have influenced her not to include it. Bridget said that she thought including orientation was a good idea, but that she had forgot about it until she read the *UCSMP* materials, but made no plans to include it after she had read it. Kelsey did not want to include orientations because it was not in the *Utah Core Standards* and chose to use non-symmetric figures to guarantee that it would not be an issue for her students. Although they did not plan to teach the orientation of a figure, students in both novice teachers' classes ended up asking about the orientations of the figures and Emma and Bridget held discussions about orientations anyways.

Teacher's orientations regarding curriculum use decisions. The orientations that I inferred influenced teachers' decisions differed across teachers. For Emma her orientation to teach in a manner that resulted in positive evaluations and her orientation that learning is best when scaffolded for difficulty seemed to influence her the most. Bridget seemed less preoccupied by how she was evaluated, but had the orientation to teach in a manner that gave students real experience and for her to teach the content that she and her team planned to address. Kelsey seemed most influenced by her orientation to the *Utah Core Standards*, her orientation that she should adapt any material she was given, and her orientation to have students discover mathematics for themselves.

Teacher's goals regarding curriculum use decisions. There were several commonalities of the teacher mathematical goals with regards to their lesson plans. All three teachers wanted students to perform or know the rules for performing transformations on a coordinate plane. All three of the teachers also had goals for students to know the properties of transformations. Kelsey the experienced teacher was the only one who consistently seemed to have her goals guide her instruction rather than choosing goals after deciding what was going to be taught.

Teacher's resources regarding curriculum use decisions. The three teachers had a lot of similarities with regard to their resources. They all had access to a textbook adopted by their districts and the *UCSMP* materials and yet all three teachers chose to disregard the majority of these materials and found other curriculum sources. It does seem clear that Kelsey, the experienced teacher, had the most knowledge about where to find resources. None of the teachers discussed much about how geometric transformations were connected to future content (i.e., congruence and similarity) or how students understanding of geometric transformations would connect to congruence. Most of the teachers seemed to lack knowledge of why the property of orientation would be important for students to learn. Both Emma and Bridget mentioned that they had been taught that the orientation of a figure was important, but neither said why or made plans to teach it. Kelsey did not even mention hearing the orientation of a figure was important. She indicated that the orientation of a figure was not in the *Utah Core Standards* for grade 8 and was therefore not a topic that was important for her students at this time.

The teachers differed mainly in their resources with regards to knowledge of students and pedagogical content knowledge. Both of the novice teachers gave little indication of their knowledge of how students were going to react to the lessons they had planned. Bridget especially made little to no reference of how students were going to react, while Emma seemed to focus on what students would not be able to do. Kelsey on the other hand gave a lot more thought to how students were going to think and react to different prompts and activities and then designed her lessons around how she anticipated what students would do. With regards to pedagogical content knowledge Emma had several indications that at times she would not know how to teach a specific topic, which may have led her to rely heavily on the materials she was given. The other two teachers seemed confident in the manner they were leading their students through the content.

CHAPTER 5: DISCUSSION

In this section, I discuss the results of the study in comparison to other studies and research in order to address my research questions of, what decisions do teachers make to follow, adapt, or omit curriculum materials as they plan, and what reasoning (i.e., orientations, goals, and resources) influences teachers' decisions to follow, adapt, or omit curriculum materials?

Curriculum Use Decisions

As mentioned in Chapter 1, common ways of categorizing curriculum use decisions involved teachers being labeled into one of three groups: followers, adapters, and omitters (Lambdin & Preston, 1995; Remillard & Bryans, 2004; Stein et al., 2007); based on how they used a specific curriculum resource. Other research implies that teachers are capable of being all three types of curriculum users (Brown, 2002; Lloyd, 2008; McDuffie & Mather, 2006). The results of my study align with the aforementioned studies in that all three participating teachers made decisions to follow, adapt, and omit; although, the three teachers made the majority of their decisions in one type of curriculum use category.

While the variation in how the teachers used curriculum in this study coincided with previous research, this study is unique in the fact that the adapt category was expanded and that a new curriculum use category was introduced. The common view of an adaptation in the literature was vague and hard to make sense of. Consider two examples of adaptations from my study. First, in Emma's translation lesson she added a discussion to describe the procedure for translating figures on a coordinate plane as a "code," rather than a procedure or rule. While vocabulary is important to mathematics, this adaptation seems to have little impact on the overall content and goals of the curriculum materials she was using. Second, in Kelsey's rotation lesson she changed several problems from the curriculum she was working with that originally had students rotate figures around various points, to having students only rotate these figures around the origin. This adaptation significantly changed what students had the opportunity to learn and understand.

All three teachers also made decisions with regard to no curriculum materials, which resulted in the need for the creation of the *self-create* category. The novice teachers made self-create decision in creating their goals, but used other curriculum materials in making all their other decisions. Meanwhile, the majority of the experienced teacher's decisions were to *self-create*. She ended up not only self-creating her goals, but all self-created all but one task she used in her geometric transformations unit.

Another, unintentional, result of this study was expanding the practice of analyzing teachers' curriculum use decisions with regards to only one specified curriculum material. Commonly a teacher was labeled as one who follows, adapts, or omits based on their decisions regarding one or two specific curriculum materials (Lambdin & Preston, 1995; Remillard & Bryans, 2004; Stein et al., 2007). Given that all three teachers omitted the *UCSMP* materials they would have been labeled as omitters by other researchers and would have been viewed as using curriculum in relatively the same manner. By expanding my analysis to look at the decisions the teachers made with curriculum materials other than the *UCSMP* materials, allowed for a more complete vision of the curriculum use decisions the teachers made. Through the expanded analysis, it can readily be seen that the teachers made different decisions and had different reasoning for their decisions in their plans such as: what type of curriculum materials they choose to use, whether or not they used tasks, what mathematics content was specifically taught, and the reasoning for rejecting the *UCSMP* materials.

Difference between Novice and Experienced Teachers

My study aligns with other studies in the differences found between the curricular decisions of novice and experienced teachers. Many studies on teachers using curriculum materials indicated that novice teachers were more inclined to *follow* their curriculum materials than experienced teachers (Behm & Lloyd, 2009; Borko & Livingston, 1989; Remillard & Bryans, 2004; Sherin & Drake, 2009). This was true in my study. Almost 50% of Emma's decisions were to follow her materials and Bridget made nearly 80% of her decisions to follow, while Kelsey made under 20% of her decisions to follow. Likewise, Kelsey was the only teacher that made adaptions that significantly changed the content of the materials she used to plan her lessons. Some studies, such as Behm and Lloyd (2009) identify that novice teachers are capable of omitting materials and some are more likely to omit rather than follow. While both of the novice teachers were more likely to follow than to omit, they both did make omissions.

There were other differences between the novice and experienced teachers in my study. For instance, Kelsey, the experienced teacher, was much more likely to think about how students were going to react to the tasks than the novice teachers. Likewise, Kelsey used her mathematical goals to guide her lesson development. Emma seemed to choose her goals more from the materials she was using than having goals that aided her in choosing what to teach. Bridget was very inconsistent in goals and often her goals did not align with what she taught. Kelsey on the other hand specifically designed her tasks based on her goals. Given that having clear established mathematical goals guiding your planning has shown to be a productive practice (Hiebert et al., 2003; NCTM, 2014; Sleep, 2012; Wiggins & McTighe, 2006). While Kelsey had more knowledge and skills to address teaching in general the two novice teachers seemed to have more content knowledge about geometric transformations. Both of the novice teachers were more familiar with the properties of transformations and had heard of topics like the orientation of a figure and glide reflections and indicated that they had been taught these topics were important. Kelsey seemed less familiar with geometric transformations and based what she knew about them off of the *Utah Core Standards*. It is interesting to note that while the novice teachers were more familiar with the content than the experience teacher, all of the teachers decided to address the same content and not address important concepts (e.g., orientation of a figure) in their lesson plans.

Problematic Trends in Geometric Transformations Decisions

Although the three teachers used different curriculum materials in planning their lessons on geometric transformations, their lessons had some surprising similarities. Emma and Kelsey focused on the properties of geometric transformations that are listed in the *CCSSM* (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010) or *Utah Core Standards*: (a) Lines are taken to lines, and line segments to line segments of the same length; (b) Angles are taken to angles of the same measure; and (c) Parallel lines are taken to parallel lines. While Bridget only discussed one of these properties, that side lengths are preserved when reflected. Most of the teachers also only explicitly addressed these properties once in the data collection period and not with regards to each transformation (an exception being Kelsey's reflection homework). This is problematic given that in high school students will focus on understanding congruence of shapes in terms of rigid motions or transformations (National Governors Association Center for Best Practices Council of Chief State School Officers, 2010). By knowing that these properties hold true for transformations, students will be able to build off this and know that these properties hold true for congruent figures as well.

Knowing these properties might also aid students in high school to decide whether two figures have been transformed or not.

Similar to many of the textbooks discussed in Kasmer, Teuscher, Dingman, & Olson's (2015), none of the teachers specfically discussed the orientation of a figure in regard to geometric transformations. Knowing about the orientation of a figure is important because it can help students identify which transformation was used to go from pre-image to image. For example, if you were to look at figure 14 without focusing on the orientation of the figure, it would be difficult to distinguish whether a rotation or a reflection took place. It is only through the examination of the figure's orientations and the fact that rotations preserve orientations and reflections do not that one can identify the figure was rotated.

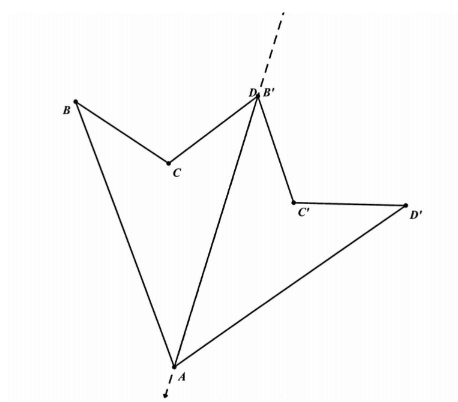

Figure 14. Example of identifying a transformation where orientation is helpful. Adapted from *The University of Chicago School Mathematics Project's* geometry textbook (p. 195), by Benson et al., 20016.

In her reflection lesson, Kelsey was worried that some of her students would get confused between reflections and translations if given symmetric shapes. By knowing that translations preserve orientations and reflections do not, she could have cleared up this confusion. Instead Kelsey avoided the issue altogether and decided to use only non-symmetric shapes limiting the types of problems the students could do.

The teachers likewise excluded teaching about glide reflections and isometries, which Usiskin (2014b) indicates are topics excluded from many textbooks. By teaching students about glide reflections students could be familiar about all four of the transformations that preserve congruence or all isometries. This again is knowledge that would be useful in high school when students are learning about congruence. By knowing all four transformations and the specific properties of those transformations, such as whether or not they preserve orientation or distance between a line of reflection, students can know for sure if a transformations occurred, which transformation occurred, and therefore whether figures are congruent or not.

The teachers taught in a manner that was problematic in terms of the specific transformations they taught as well. For example, Stacey, Price, Gvozdenko & Steinle (2013) claims that there were four levels of understanding reflections in middle school. At stage 1, students have an understanding of reflections as a general idea of *what* a reflection is. At stage 2, students understand how to reflect points and images over horizontal and vertical lines. At stage 3, students understand how to reflect a simple shape across any line (i.e., oblique lines). At stage 4, students understand how to reflect a complex shape over any line. The aforementioned study also found common errors when students worked with reflecting shapes include: orienting complex figures as if they were reflected horizontally or vertically when they are reflected over oblique lines or reflecting shapes to make them look visually “balanced” rather than keeping points equidistant from lines of reflection. To overcome these misconceptions and get students to higher stages of learning teachers should expose students to transformations over oblique lines and explicitly teach the property of the preservation of distances between points and lines of reflections when reflecting. The teachers in my study only had students do reflections with lines of reflection that can easily be transformed on a coordinate plane (i.e., the x-axis, the y-axis

$y = x$, and in some cases $y = -x$) and had no experience in reflecting over other oblique lines. Likewise, neither Bridget or Kelsey (the teachers I interviewed about their reflections lesson) explicitly taught the property of the preservation of distances between points and lines of reflections when reflecting – although this was one of Bridget's mathematical goals.

Stacey et al. (2013) also have developed stages, misconceptions, and teaching tips for teaching rotations in middle school. They indicated that a stage 1 understanding of rotations consisted of students being able to recognize a radius rotated in a circle about a center, a stage 2 understanding implies that students can recognize a rotation using a radial line or a line that passes through the center of a circle, stage 3 required students to perform rotations using a radial line, and a stage four understanding indicates that students could recognize correct rotations of objects with no radial line. The researchers indicated that common misconceptions of rotations included not realizing that rotations preserved distance from images to centers of rotation, that students keep the slopes of lines preserved, and that students cannot identify centers of rotations given two images that have been rotated. The researchers indicate that to overcome these misconceptions and build understanding teachers should give students practice performing rotations, paying special attention to the center of rotation and use a variety of centers of rotations, and the property of preserving distance between rotated figures and the center of rotation. All of the teachers interviewed about their rotations lesson in my study only used the origin as the center of rotation, never used radial lines, and did not teach the property of preserving distance between rotated figures and the center of rotation. Likewise, they only used rotations of 90-, 180-, or 270-degree angles, which limits the number of rotations that students can perform.

Reasoning

Research indicates that there are a variety of orientations and resources that affect the way in which teachers use curriculum materials (Lloyd, 2008; Lloyd et al., 2009; Remillard, 2005; Remillard & Bryans, 2004; Stein et al., 2007). With regards to orientations Remillard & Bryans (2004) found that orientations towards curriculum materials, teaching, and learning were some of the most influential factors for teachers as they used curriculum materials. These orientations were very influential in how the teachers in my study made their decisions in planning their lessons. All three teachers' orientations towards teaching were some of the main determinates in their goals for their lesson plans and ultimately their decisions. All three teachers had very different orientations towards teaching. Emma's orientations towards teaching focused on getting approval from others and teaching topics that seemed interesting to her, Bridget's orientations towards teaching revolved around covering content and teaching for discovery/application, and Kelsey's orientations towards teaching focused on teaching in a task-based manner. Orientation towards curriculum materials was influential to Bridget and particularly Kelsey. Bridget seemed satisfied with materials that basically covered the content that she wanted. Kelsey was more selective and based her orientations on whether curriculum materials aligned with the *Utah Core Standards*. Emma was influenced more by her orientation towards learning than the other two teachers. She indicated that topics need to be scaffolded for students to learn best while the other teacher mentioned little about what led to student learning.

Researchers have indicated that resources that may affect how teachers use curriculum materials include content knowledge, pedagogical content knowledge, undergraduate and graduate coursework, school resources such as department curriculum materials, expectations from administrators or other teachers, and experience (Lloyd, 2008; Remillard, 2005). All of these factors affected the teachers in my study in some manner, but differed across the teachers. One limiting factor for all the teachers seems to be their lack of content knowledge. None of the teachers seemed to understand how the orientation of a figure fit in geometric transformations or why it was important to teach. This may have been a possible factor that guided them to excluding the property of orientation and the *UCSMP* materials. Both of the novice teachers did seem to have more knowledge of the orientation of a figure and glide reflections in general than Kelsey, which may have resulted from their recent undergraduate coursework in mathematics education. Emma seemed to be the teacher influenced most by school context and many of her decisions to succeed and meet expectations of those overseeing her. Another factor that researchers indicate can affect teacher's planning and instruction is their curricular knowledge (Ball et al., 2008; Shulman, 1986). This seemed particularly influential for Bridget who did not know or have the capacity to find materials that would meet her goals and for Kelsey who had access to a vareity of sources in gaining materials and was able to draw on these well, but seemed to have a skewed understanding of what the standards discussed.

CHAPTER 6: CONCLUSION

In this study, I sought to expand the field's understanding of how teachers use curriculum materials and their reasoning for those decisions while planning. Due to the relative "newness" and problems found in textbooks regarding geometric transformations, I specifically focused on teachers' decisions and reasoning when planning lessons on this content. I found that while all the teachers omitted the *UCSMP* materials I gave them to plan lessons, they made a variety of curriculum use decisions using other curriculum materials. Likewise, I found that the three teachers taught geometric transformations with a heavy focus on transforming shapes on coordinate planes, but lacked addressing important definitions and properties of geometric transformations.

Limitations

Initially the fact that none of the teachers used the *UCSMP* materials as a major resource in planning their lessons on geometric transformations was a limitation. This omission of the *UCSMP* materials made it so that it was not as easy to compare the teachers and to note which aspects of the curriculum materials were most useful to the teachers and which aspects were not. On the other hand, by examining all the materials teachers used I was able to paint a portrait of how the teachers would plan in an ordinary situation and see which materials the teachers used and which materials they did not use. As well as notice that although the materials were different for each teacher the three teachers made similar decisions in choosing what content to teach. There needs to be more research conducted on studying how teachers use particular textbooks as this will help gain knowledge for developing better textbooks and understanding which aspects are particularly helpful or not-so-helpful to teachers as they plan.

A similar limitation was that I was not able to interview each teacher about each lesson in their geometric transformation unit or interview each teacher on the same topic, which made it more difficult to compare the teachers. I did conduct interviews with at least two teachers per topic, but due to scheduling conflicts was unable to collect data on the same lessons or all the lessons with each teacher.

A third limitation of this study was that I only had three teachers participate in this study. This limitation was due to the need for close analysis of multiple interviews and lesson plans of the teachers. In the future, it would be interesting to have a similar study using more teachers and to see whether the majority of teachers would omit the *UCSMP* materials, teach geometric transformations in a similar manner, and to see what resources teachers' drew on to plan for the content.

Another limitation was the fact that I did not observe the teachers' implemented lessons. In interviewing the teachers about the lessons they were teaching I was able to glean some information about how their plans changed as they implemented prior lessons, but it was not as complete of a view as some of the others studies that have observed the teachers enacted lessons. Both of the novice teachers indicated that they taught content they specifically chose not to plan for, but was brought up by their students. In the future, researchers could gain more insight about what strengths and weaknesses the teachers had in planning by watching the implemented lessons.

The last limitation of my study was that I had to infer which reasoning influenced the teachers and to what extent the different reasoning affected their decisions. Researchers indicate that it is often difficult to truly identify the beliefs of individuals. Many of my inferences of beliefs and goals stemmed specifically from what the teachers said their beliefs and goals were, which may or may not be accurate.

Contributions and Implications

This study contributes to the mathematics education field specifically in research on how teachers use curriculum materials in three main ways. It strengthens the evidence that many teachers are omitting curriculum materials, which may hamper the reformation of mathematics teaching, it provides an expanded framework for viewing how teachers make decisions regarding specific curriculum materials, and this study provides a needed portrait on how the “new” content of geometric transformations is being interpreted and planned by teachers.

One of the major findings of this study was that all three of the teachers did not use the curricula selected by me or by their school districts as their main source in planning lessons, preferring to seek a variety of materials from different sources or creating their own. Other studies have also indicated that teachers omit entire curriculum materials (Behm & Lloyd, 2009; Manouchehri & Goodman, 1998; Remillard & Bryans, 2004). Given the fact that so many teachers are omitting materials raises many concerns. For instance, curriculum materials have long been used as a means of implementing reform practices (Ball & Cohen, 1996; Brown, 2002; Stein et al., 2007; Tarr, Chavez, Reys, & Reys, 2006) and if teachers are not using the materials that have been designed to help them teach in a reformed manner how is mathematics teaching going to change? Should the mathematics community continue to invest in creating reform-based curriculum materials or should funds and resources be used in other avenues that might elicit change? Should teachers be forced to use certain curriculum materials? In order to answer these questions I suggest that research continued to be done on the effectiveness of reform-based curriculum materials on instruction. Particularly I think it would be beneficial to study which materials have been most successful and what aspects of these materials make them more successful.

Another major concern is that if teachers are not using the curriculum materials given them, what materials are they using and how are they choosing them? In my study the teachers turned to a variety of resources including materials developed by mathematics departments at schools, online resources, resources obtain from other teachers, and resources they created themselves. The teachers also gave inconsistent and a variety of reasoning for why they chose the materials they did ranging from the teachers were expected to use them to teachers being given something that basically covered what they wanted. I believe that more research needs to be done to identify the resources teachers are drawing on most and why they are drawing on these particular resources. By knowing what resources teachers are using researchers can better evaluate the quality of what is being used for students. They can also tell if teachers are being consistent in the materials they are using and if they are choosing materials that build off of each other and use similar language and examples or if they use a variety of materials that are more disjoint. This research could especially be beneficial to teacher educators who could develop ways to help both pre-service and inservice teachers evaluate different curricular materials and become better consumers of curriculum.

My study also contributed to the mathematics education field through my expansion of the previous methods of examining how teachers use curriculum materials. One aspect of my expanded method was to analyze curriculum decisions teachers make through the lens of different curriculum materials the teachers used rather than one. By examining the decisions teachers made with regards to several curriculum materials rather than one or two I believe researchers can gain a more accurate and nuanced view of how teachers use curriculum materials as well as determine which materials are more effective in enacting change than others. By investigating how teachers use multiple materials researchers can identify patterns or inconsistencies in what the teachers choose to use that may aid researchers in identifying what makes curriculum materials worthwhile or not to a teacher. For example, suppose a teacher looks over curriculum material A and omits it giving the reasoning that the problems were too difficult, but then goes and follows curriculum material B which has problems very similar to curriculum material A. A review of the two curriculum materials might show things like the teachers liked the figures in material B or that material A did not provide enough teacher notes. This broader perspective could also aid teacher educators and professional development leaders in understanding what materials teachers are drawing on and how to best assist them in using a multitude of resources or directing them to the best resources.

Besides expanding the breadth of curriculum materials studied I also created new categories and sub-categories of curriculum use. With the creation and analysis of the *self-create* category it opens new realms of knowledge to explore. Researchers can examine whether or not teachers are developing different ideas or methods than those in popular curriculum materials. If teachers are *self-creating* the majority of their materials as in the case of Kelsey, then it could be important to examine whether or not teachers' self-created materials build on each other and are coherent through units and through different grades. With the inclusion of the new sub-categories for adapt both researchers and teachers can get a more nuanced understanding of and have a more precise language of what teachers are doing to improve or weaken curriculum materials. By looking at the particular sub-categories I created and possibly through the creation of more sub-categories, researchers might be able to determine which types of adaptations or which situations certain types of adaptations are most beneficial or most damaging.

This study also gives a portrait of what decisions teachers make when planning lessons on geometric transformations. This is especially significant given the fact that geometric transformations in the middle grades is relatively “new” (Teuscher, Tran, & Reys, 2015), and that many textbooks are incorrect or lack important content associated with geoemtric transformations such as orientaitons and glide reflections (Kasmer, Teuscher, Dingman, & Olson, 2015; Usiskin, 2014b). It is notable that despite using different materials all three teachers ended up teaching geoemtric transformations in a similar manner: focusing on performing transformations on coordinate planes and exluding teaching about orientations—a topic that since the time of the data collection for this study has been included in the mathematics standards of the state in which these teachers work. By understanding how teachers are approaching this content, teacher educators and curriculum designers can better design their lessons/materials to aid teachers in overcoming problematic trends or build content knowledge where it is lacking.

Conclusion

The main goal of the mathematics education field is to improve the teaching and learning of mathematics. One avenue many are taking in trying to improve the teaching and learning of mathematics is through the use of curriculum materials. Over the last few decades researchers have explored how teachers interact with curriculum materials. In my study, I have sought to add to this knowledge base by looking at the specific decisions and reasoning teachers make as they plan lesson on geometric transformations. I have found that teachers make a variety of decisions to follow, adapt, and omit as well as decisions to self-create. I have also found variety in the types of adaptations. Furthermore, I have found that although the teachers used different curriculum materials, many of the decisions they made relating to the content of geometric transformations were very similar and problematic for student learning.

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APPENDIX A

Individual Teacher Planning Interview Protocol

Instructions to observer:
Begin the interview by asking the teacher to describe the general outline of their lesson (in this stage of the interview make sure to record, which aspects of the curriculum materials show up in their plan and which aspects do not), next, proceed through each section of the protocol. It's okay to skip questions if the teacher has already discussed the topic in detail. When in doubt, ask the question even though the teacher may have discussed it.

1. **Information about class**(first lesson only)
    a. Describe the class for which you would teach this lesson (e.g., grade, prior mathematical achievement, size of class).

2. **Follow up on previous lesson** (Geometric transformations interviews only)
    a. How did the lesson go?
    b. What worked well?
    c. What didn't work well?
    d. Would you now change anything to your plan, now that you have taught it?

3. **Lesson Plan**
   Describe your lesson from start to finish. [Interviewer probes for **components and characteristics** of the lesson, as necessary]. In this section make notes of what aspects of the curriculum materials are used and which are not.
    a. How would you start the lesson?
    b. How would you introduce the topic?
    c. What specific problems will the students work on?
    d. What specific examples will you show
    e. What activity structures would you use
        i. whole class lecture,
        ii. whole class discussion,
        iii. small group work,
        iv. independent seat work
        v. something else (pair work, pair consultation during independent work, etc.)
    f. How would you conclude the lesson

4. **Curricular Reasoning**
    a. Why did you choose these particular activities?
    b. Why did you choose not to include ________________? (aspects of curriculum materials read but not found in plans)?
    c. Why did you choose to change ____________________?
    d. How long do you anticipate each of these activities are going to take?
        i. How will you determine when to move onto the next activity?

5. **Mathematical Content**
    a. Why did you choose to teach a lesson on this particular content? (Dig deep here)
    b. What content have students learned previously to prepare them for this lesson?

6. **Mathematical Goals**
    a. What is your mathematical goal for this lesson (what do you want students to accomplish as a result of this lesson)?
    b. Why is this your goal?
    c. Which of the activities that you have planned help most in accomplishing this goal? Why?
    d. How will you know if your students achieved this goal?

7. **Resources**
    a. Why did you choose not to read ______________ in the curriculum materials?
    b. What aspects of the curriculum materials were most beneficial in helping you plan your lesson?
    c. What other resources did you use in planning this lesson?

8. **Anticipating Student thinking**
    a. What kinds of student reasoning/ student strategies/ student misconceptions do you anticipate?
    b. How would you address or respond to the challenges and anticipated student reasoning?
    c. Do you anticipate you will need to differentiate instruction (adapt teaching in order to accommodate struggling and adept students)? How would you do so?

APPENDIX B

Plans for Lesson

Teacher Name:

Name of Lesson:

Content of Lesson:

Mathematical goals for lesson (what do you want students to have learned as a result of this lesson):

-

Basic outline of lesson (What specific activities, questions, and examples do you plan to use?):

-

What resources (e.g textbooks, websites, conversations with other teachers, computer software) did you use in planning this lesson? (If you used a website please include the URL)

-

Plans for Lesson - Example

Teacher Name: John Doe

Name of Lesson: Section 4.1, Experimental Probability

Content of Lesson: Experimental Probability

Mathematical goals for lesson (what do you want students to have learned as a result of this lesson):

- Students will know that probability represents the likelihood that an event will occur, given a large number of trials.
- Students will be able to calculate experimental probabilities given a data set.

Basic outline of lesson (What specific activities, questions, and examples do you plan to use?):

- Students will complete true and false quiz (see attached)
- Students will discuss possible answers to the following statements
    - There is a ____ % chance of rain today.
    - The probability that BYU will win their next basketball/football game is ____.
    - The probability that if I flip two coins, both of them will be heads is ____.
- Class discussion will then be held – focus is on what the values students give mean. Bring up the following.
    - Probability values are between 0 and 1
    - Probabilities are the expected outcome of repeated events
- Coin Flip activity (see attached)
- Hershey Kiss activity (see attached)
- Discussion of factors that affect experimental probabilities
    - Randomness
    - Variations of conditions
    - Law of large numbers
- Homework 4.1 all problems (see attached)

What resources (e.g textbooks, websites, conversations with other teachers, computer software) did you use in planning this lesson? (If you used a website please include the URL)

- Ambiguous textbook chapter 4.1
- Not a real website, accessed at notarealwebsite.com

APPENDIX C

Decisions Sheet

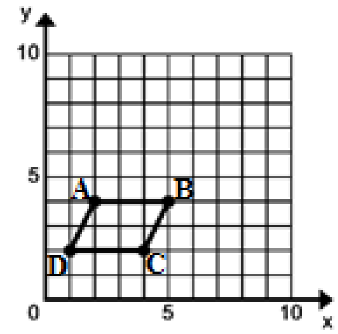
Decision	Followed (F), Adapted(A) Omitted (O), or Other Resource (OR)	How was the decisions adapted or omitted?

Name: ______________________________ Period: __________ Date: ____________

Intermediate 2	**In Class 9-1** **Translations**	**Unit 9**

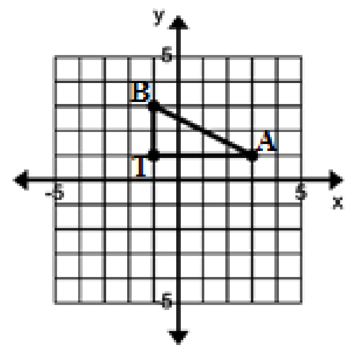
Translate means slide or glide.

1) ▱ABCD has vertices A(2 , 4), B(5 , 4), C(4 , 2), and D(1 , 2). **Graph and label the vertices of ▱A'B'C'D' after a translation of 3 units right and 4 units up.**



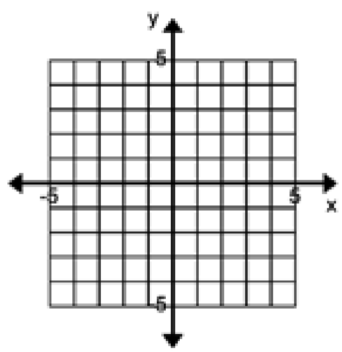
A'(,), B'(,)
C'(,), D'(,)

2) △BAT has vertices B(-1 , 3), A(3 , 1), and T(-1 , 1). **Graph and label the vertices of △B'A'T' after a translation of 2 units left and 5 units down.**



B'(,), A'(,), T'(,)

3) Graph ▱OREM with vertices O(-5 , 3), R(-1 , 3), E(-1 , 1), and M(-5 , 1). **Then, graph and label the vertices of ▱O'R'E'M' after a translation of 4 units right and 2 units down.**



O'(,), R'(,)
E'(,), M'(,)

Translation notation: $(x,y) \to (x+a, y+b)$

4) Translate the following ordered pairs 2 units right and 3 units down.

a) $(4,2) \to (\quad , \quad)$

b) $(-6,5) \to (\quad , \quad)$

c) $(0,-2) \to (\quad , \quad)$

d) Fill in the translation notation.

$(x,y) \to (\qquad , \qquad)$

5) Translate the following ordered pairs 3 units left and 5 units up.

a) Fill in the translation notation.

$(x,y) \to (\qquad , \qquad)$

b) $(2,-3) \to (\quad , \quad)$

c) $(-1,8) \to (\quad , \quad)$

d) $(5,-6) \to (\quad , \quad)$

6) Translate the following ordered pairs $(x, y) \to (x-2, y+3)$.

a) Will this translation move the pre-image left or right? Up or down?

b) $(2,-3) \to (\quad , \quad)$

c) $(-1,8) \to (\quad , \quad)$

d) $(3,-5) \to (\quad , \quad)$

7) $\triangle MRH$ has vertices M(-1 , -2), R(4 , -2), and H(4 , 7). Translate $\triangle MRH$ 3 units right and 4 units up and label the image's vertices.

a) Fill in the translation notation.

$(x,y) \to (\qquad , \qquad)$

b) $M'(\quad , \quad)$

c) $R'(\quad , \quad)$

d) $H'(\quad , \quad)$

8) ▱UTAH has vertices U(0 , 3), T(4 , 3), A(1 , -1), and H(-3 , -1). Translate ▱UTAH $(x+4, y-3)$ and label the image's vertices.

a) Will this translation move the pre-image left or right? Up or down?

b) $U'(\quad , \quad)$

c) $T'(\quad , \quad)$

d) $A'(\quad , \quad)$

e) $H'(\quad , \quad)$

9) Point C is translated 3 units right and 2 units down. What are the coordinates of C'?

$C'(\quad , \quad)$