THE IMPACT OF HIGH SCHOOL MATH TEACHERS' CONCEPTIONS OF TEACHING AND LEARNING ON IMPLEMENTATION OF STUDENT-CENTERED INSTRUCTIONAL PRACTICES

by

Melissa Marie Lute

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

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ABSTRACT

The purpose of this quantitative, predictive, correlational study is to investigate the relationship between high school math teachers’ conceptions of constructivist instructional practices and their conceptions of traditional teaching practices with their implementation of student-centered learning (SCL) practices in their math classes. Cognitive constructivism, theories of teacher beliefs, and teacher self-efficacy provide a theoretical framework for understanding math teachers’ beliefs about teaching and learning and their use of SCL. This quantitative, nonexperimental study uses a correlational research design to investigate teachers' conceptions of teaching and learning and their implementation of student-centered instructional practices. The convenience sample included 68 high school math teachers in South Carolina. The teachers submitted online responses to the Teaching and Learning Conceptions Questionnaire (TLCQ), which produces two scores, one on constructivist conceptions and one on traditional conceptions. The teacher participants were also observed using the Reformed Teaching Observation Protocol (RTOP) to determine the extent which they use SCL practices in their classes. Using multiple linear regression analysis, the researcher examined the results of the TLCQ and RTOP. The results of the study show that the linear combination of teachers' conceptions of constructivist teaching practices and traditional practices may predict the level of student-centered instructional practices used in their math classes. Future research studies should consider using multiple observations, including other factors such as experience and self-efficacy, and a larger sample with a more diverse population.

Keywords: Student-centered learning, secondary mathematics, teachers' conceptions, constructivism, reform-based mathematics

Copyright Page (Optional)

Dedication

To my husband, Joe, who is my rock on this earth always and especially throughout my doctoral journey and entire education career. Through the tears and joys, his support and understanding helped motivate me to push through. He never complained about carrying my weight around the house, cooking or cleaning, or when I spent countless hours on weekends working. Without him, I would not have made it this far.

Also, to my mother, Pattie, who is the strongest woman I know. When I felt little confidence in myself, she was always there to encourage and motivate me. She regularly reminded me that God has a plan for everyone, and this was part of mine. Her reminders and encouraging words helped me in some of my most challenging moments.

To anyone who is willing to try something out of their realm, even if others think it cannot be done or it is not worth the time or effort. Go for it.

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I am grateful to my family for supporting me through this journey. I am especially thankful to my husband, Joe. Without his support, I would have never made it this far. Thanks to my mom, Pattie, who is my biggest cheerleader. I am grateful for the support and encouragement from both of my parents, Pattie and Ed, and my sister Jessica.

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List of Abbreviations

Student-centered learning (SCL)

Professional Development (PD)

National Center for Educational Statistics (NCES)

National Council of Teachers of Mathematics (NCTM)

Teaching and Learning Conceptions Questionnaire (TLCQ)

Reformed Teaching Observation Protocol (RTOP)

CHAPTER ONE: INTRODUCTION

Overview

The purpose of this quantitative, correlational study is to investigate if there is a relationship between high school math teachers' conceptions of teaching and learning and the extent to which they implement student-centered instructional practices in their classes. This chapter will include the background related to student-centered instructional practices and high school mathematics teacher professional development (PD). The research problem, purpose, and significance will also be identified, followed by the research questions to be studied.

Background

Instruction design using constructivist principles is considered student-centered, as opposed to traditionally teacher-centered methods. Although many high school math teachers are aware of the positive impact of student-centered instructional practices on student achievement, they continue to use the traditional teacher-directed model (Davis et al., 2020; Eronen & Kärnä, 2018; Wilkie, 2019). Following the development of the Common Core State Standards for Mathematics in 2010, the National Council of Teachers of Mathematics (NCTM) developed principles that guide mathematics instruction to help improve student achievement in mathematics (NCTM, 2014). Based on these principles, student-centered instructional practices such as task-based learning, productive mathematical discourse, and exploration of contextual mathematical problems are deemed more appropriate for use in the math classroom than traditional teacher-directed teaching (NCTM, 2014). Although teachers are exposed to student-centered instructional practices during professional development (PD) activities, many do not implement or sustain implementation in their math classrooms (Copur-Gencturk & Papakonstantinou, 2016; Davis et al., 2020; Valoyes-Chávez, 2019; Wilkie, 2019).

Student-centered learning (SCL) involves all students as active participants in their learning experiences. This approach contrasts with traditional learning through teacher-centered instruction, where students are typically passive learners, receiving knowledge from the teacher (Reigeluth et al., 2017). In student-centered instruction, the role of the teacher and student changes such that the student becomes an active participant in what they are learning, with the teacher facilitating the learning process (Keiler, 2018; Reigeluth et al., 2017). According to Sawada et al. (2002), reformed instruction and learning is a change from traditional instruction to more constructivist-based practices, such as SCL. In mathematics, Talbert et al. (2019) suggested that SCL has a more substantial effect on student engagement than teacher-centered instruction. SCL is an extreme change from traditional teaching and learning, and is thus considered a reformed approach. Teachers may reform their math classes, incorporating more student-centered instructional practices such as mathematical tasks, mathematical discourse, and activities that allow students to explore concepts and generate new knowledge through making connections with prior knowledge (Bishop et al., 2018; Copur-Gencturk & Papakonstantinou, 2016; NCTM, 2014; Talbert et al., 2019).

The extent to which high school math teachers implement SCL in their classrooms may be directly related to their beliefs on teaching and learning. Teachers with positive beliefs about constructivist teaching and learning are more likely to report using constructivist practices in their classrooms (Dejene, 2020; Yang et al., 2020). However, some teachers with positive beliefs about constructivist learning do not necessarily utilize such instructional practices (Lau, 2021; Yurekli et al., 2020). Teachers who have a better understanding of SCL approaches tend to feel more comfortable implementing them in their classrooms (Berger & Lê Van, 2019; Davis et al., 2020; Keiler, 2018; Klein & Leikin, 2020; Xie & Cai, 2020). To help support implementation of

SCL in math classes, schools and districts can provide high school math teachers with ongoing support and training (Hayward & Laursen, 2018; Keiler, 2018). Just as students are expected to be active learners in mathematics, a key feature of teacher PD is active engagement in analyzing teaching and learning practices (Desimone et al., 2002). Therefore, for teacher PD to effectively address the importance of SCL approaches, it should be designed using features of SCL.

Historical Overview

In the 1980s in the United States, the National Council of Teachers of Mathematics (NCTM) led the education standards movement by publishing standards for teaching and learning mathematics (NCTM, 2014). In 2010, the Common Core State Standards for Mathematics were released, and implementation began in 2011 by 45 states (Common Core State Standards Initiative, 2021). Since then, many states have either revised the Common Core standards or adopted their own state standards (EdGate, 2022). There are currently 25 states and Washington, D.C. using Common Core standards and 25 states that use revised, or state-adapted, standards (EdGate, 2022). The Common Core standards are research-based and outline the skills and knowledge students should have upon high school completion (Common Core State Standards Initiative, 2021). In addition to the content standards, a set of mathematical practices were created to inform teaching and learning mathematics (NCTM, 2014). There are eight practices in all that relate to reformed instructional practices in the math class, such as incorporating math tasks that promote reasoning and problem solving, establishing math goals to facilitate learning, and eliciting and using evidence of student learning (NCTM, 2014).

In the United States, in-service public-school teachers are expected to participate in professional learning activities to stay up-to-date with current educational practices. Different types of professional learning activities may include PD workshops, school or district-based PD, conferences, coaching sessions, and professional learning communities. To improve instructional practices, key features of teacher PD include collective participation, program duration, ongoing support, and incorporating content knowledge (Desimone et al., 2002; Guskey, 2002; Kennedy, 2016). PD for high school math teachers should include mathematical knowledge for teaching, as well as pedagogical content knowledge (Hill & Ball, 2004; Shulman, 1986). That is, PD for high school math teachers should involve research-based SCL practices in secondary math classes.

More recently, research studies have indicated that PD that aims to change math teachers' instructional practices must also incorporate elements that increase teachers' self-efficacy and beliefs regarding content and instructional approaches (Copur-Gencturk & Papakonstantinou, 2016; Wilkie, 2019). Copur-Gencturk and Papakonstantinou (2016) suggested that PD that actively engages learners and provides ongoing support also enables math teachers to sustain changes to their instructional practices. Wilkie (2019) concluded that teachers responded differently to PD attempting to change instructional practices; however, when they used instructional tasks, they were more open to discussing approaches and implementation. Math teachers and their students are likely to benefit from PD that incorporates these features through increased student achievement.

Society-at-Large

In the United States, student achievement in mathematics has been an ongoing topic of concern. According to the National Center for Education Statistics (NCES, 2020a), twelfth grade American students' math scores on the National Assessment of Educational Progress (NAEP) have consistently remained unchanged since 2005. On the Program for International Student Assessment (PISA) in 2018, the average score for the United States was lower than the international average, and below 30 other countries' averages (NCES, 2020b). Based on studies that show an increase in student achievement through SCL, teachers who utilize student-centered practices in high school mathematics classes may positively impact this historically low student achievement (Bishop et al., 2018; Talbert et al., 2019).

Students who experience SCL activities, such as task-based learning, tend to have higher success rates in their math classes than those who learn from teacher-centered approaches (Bishop et al., 2018; Talbert et al., 2019). Additionally, SCL helps students develop skills that increase their higher-order thinking skills, which are valuable in society (Reigeluth et al., 2017). PD can help teachers sustain the implementation of student-centered practices in their math classrooms (Akhter et al., 2018; Copur-Gencturk & Papakonstantinou, 2016; Hayward & Laursen, 2018). Additionally, school and district leaders may influence teachers' identities, self-efficacy, and beliefs regarding instructional practices through targeted PD training (Heyd-Metzuyanim, 2019; Wilkie, 2019). Therefore, PD concerning SCL strategies may help teachers further understand and believe in the importance of SCL in the secondary math class.

Theoretical Background

SCL is grounded in cognitive constructivism, which holds the belief that knowledge is constructed through social interactions (Vygotsky, 1978). Mathematical discourse and task-based learning are key elements of building effective mathematics practices (NCTM, 2014). These practices require students to communicate mathematically and collaborate with their peers, which involves actively learning from their peers. These are also essential aspects of cognitive constructivism (Bruner, 1971; Stapleton & Stefaniak, 2019; Vygotsky, 1978). Teachers should give students opportunities to construct knowledge by engaging them in authentic tasks (Reigeluth et al., 2017). However, teachers must also recognize and value the importance of implementing SCL.

Theorists in mathematics education consider affect an essential component in mathematics teaching and learning (McLeod, 1992; Schoenfeld, 1998). Beliefs, attitudes, and emotions are three main constructs in the affective domain (McLeod, 1992). Teachers' beliefs about the nature of mathematics, the teaching and learning processes, and roles of different instructional methods affect their classroom actions (Schoenfeld, 1998). Within a teacher's belief system is their self-efficacy towards implementing new instructional practices and pedagogies (Pajares, 1992). Teachers' beliefs are shaped by their experiences, and these beliefs and self-efficacy affect their classroom practices (Guskey, 2002; Pajares, 1992). Therefore, PD plays an essential role in shaping teachers' beliefs (Guskey, 2002). According to Guskey (2002), teachers' beliefs and attitudes are likely to change when they and their students experience success from changes in teaching and learning practices. The theoretical framework for this study is grounded in constructivism, teachers' beliefs of teaching and learning, and teacher self-efficacy.

Problem Statement

Educators and parents believe that mathematics instruction should be taught using traditional teaching approaches (Davis et al., 2020). However, recent literature has indicated that student-centered approaches to learning mathematics may be more beneficial to students than teacher-centered instruction (Bishop et al., 2018; Talbert et al., 2019). In secondary and post-secondary math classes where teachers use student-centered instructional practices, such as task-based learning and problem-based learning, student achievement is higher than in those classrooms where teacher-led methods are used (Bishop et al., 2018; Talbert et al., 2019). Although research supports the value of student-centered instruction in math classes, teachers face barriers, such as their learning beliefs, self-efficacy, and perceived student background when implementing SCL and thus, cannot sustain the implementation of the practices in the classroom (Akhter et al., 2018; Corkin et al., 2019; Yurekli et al., 2020).

Research regarding teachers' beliefs and attitudes around SCL has indicated that teachers are aware of the benefits of SCL for students (Akhter et al., 2018; Davis et al., 2020; Keiler, 2018; Klein & Leikin, 2020; Xie & Cai, 2020). However, some high school math teachers are reluctant to implement SCL in their classes (Valoyes-Chávez, 2019; Wilkie, 2019). Researchers have suggested further studies that use classroom observations to determine use of SCL in math (Xie & Cai, 2020). Yurekli et al. (2020) studied teachers' beliefs about teaching mathematics by building conceptual understanding but utilized teachers' self-reported use, not their observed use, of instructional practices. Similarly, Yang et al. (2020) found that pre-service math teachers who had constructivist pedagogical beliefs reported using SCL practices. While these studies address relationships between teachers' beliefs about teaching and learning math, they rely on teachers' reported use of constructivist practices rather than their observed use. The problem is that the literature has not fully addressed the relationship between high school math teachers' conceptions of student-centered instructional practices for teaching and learning mathematics and the extent to which they implement or sustain implementation.

Purpose Statement

The purpose of this quantitative, predictive, correlational study is to investigate the relationship between high school math teachers' conceptions of constructivist instructional practices and their conceptions of traditional teaching practices with their implementation of SCL practices in their math classes. This study will explore the relationship between teachers' constructivist conceptions of teaching and learning and the extent they use SCL, teachers' traditional conceptions of teaching and learning and the extent they use SCL, and the combination of their constructivist and traditional conceptions and the extent they use SCL.

The predictor variables are math teachers' scores on the constructivist conceptions of teaching and learning scale and their scores on the traditional conceptions of teaching and learning scale. Traditional conceptions include beliefs that teaching transfers knowledge from teacher to student; the teacher is the active participant, and the student is the passive participant (Chan & Elliott, 2004). Constructivist conceptions include beliefs with the learner as an active participant who constructs knowledge through reasoning and justification (Chan & Elliott, 2004). The criterion variable is the observed extent to which teachers implement SCL instructional practices in high school math classes. Teacher implementation of reform-based practices involves having prepared lessons that allow students to actively explore new concepts based on prior knowledge while utilizing mathematical communication, critical thinking, and reflective practices (Sawada et al., 2002). Reformed teaching and learning involve the transition from traditional teaching practices to constructivist approaches, such as SCL (Sawada et al., 2002). The population for this study is high school math teachers in a large school district in South Carolina. The math teachers attend PD geared towards SCL and receive ongoing support from school and district personnel.

Significance of the Study

This study is significant in exploring how mathematics teachers' beliefs regarding teaching and learning impact how often they utilize SCL approaches in their classes. As previously discussed, student-centered methods have shown increases in student achievement in mathematics more than teacher-centered methods (Bishop et al., 2018; Talbert et al., 2019). If teachers do not implement student-centered instructional techniques because they do not recognize the value in them, they may put their students at a learning disadvantage. The current study is significant because it will add to the existing knowledge on teachers' conceptions of SCL (Akhter et al., 2018; Berger & Lê Van, 2019; Wilkie, 2019; Xie & Cai, 2020). For instance, Xie and Cai (2020) studied the relationship between teachers' beliefs about mathematics teaching and learning and their reported use of reform-based instruction. Wilkie (2019) explored the relationship between teachers' beliefs and their observed attempts at changes in instructional practices. However, little is known about high school math teachers' beliefs regarding teaching and learning and their observed instructional practices.

This study will also add to the literature that suggests teachers' beliefs towards certain instructional practices may impact the frequency to which they implement SCL practices in their classes (Akhter et al., 2018; Davis et al., 2020; Yurekli et al., 2020). Owens et al. (2018) ranked high school math teachers' PD preferences based on their reported priority level. Some top preferences included using real-world issues in class, inquiry-based activities, and problem-based learning (Owens et al., 2018). This finding may indicate that teachers may value SCL but need additional training. Akhter et al. (2018) found that elementary school teachers place a high value on student-centered approaches, but this finding does not address high school teachers' beliefs. Dejene (2020) compared pre-service teachers' conceptions of teaching and learning to their self-reported teaching approach, not observed. These studies do not address the relationship between teachers' conceptions of teaching and learning and their observed practical use of SCL strategies in their high school math classes. Therefore, the present study aims to add to this current literature by investigating the relationship between teachers' conceptions of instructional practices and their use of SCL practices in a mathematics classroom.

Research Question

RQ1: How accurately can the reform-based practices score, which measures the extent of SCL practices, be predicted by the linear combination of teacher conceptions of constructivist and traditional teaching and learning?

Definitions

The following terms are pertinent to the study of teachers' conceptions and implementation of student-centered instructional practices:

1. *Conceptions of teaching and learning* – The beliefs that teachers have about their preferred methods of teaching and learning, including the role of both teacher and student (Chan & Elliott, 2004).
2. *Inquiry-based learning* – A form of learner-centered instruction that deeply engages the student in inquisitive collaboration and communication with their peers (Hayward & Laursen, 2018).
3. *Mathematical discourse* – Students actively participate in meaningful discussions about mathematical reasoning and approaches to problem-solving (NCTM, 2014). Students listen to their peers and constructively critique their reasoning using examples and counterexamples (NCTM, 2014). The teacher purposefully plans questions and problems that facilitate whole-class and small-group discussions (NCTM, 2014).
4. *Problem-based learning (PBL)* – A learner-centered approach to learning that incorporates relevant and real problems students use to plan, investigate, explain, and communicate their findings (Lee & Blanchard, 2019).

5. *Professional development (PD)* – A means to develop and deepen teachers' content knowledge and instructional practices (Desimone et al., 2002). PD can occur through (but is not exclusive to) workshops, professional learning communities (PLCs), school or district-based activities, and coaching programs (Kennedy, 2016).
6. *Reformed teaching* – Teaching that empowers students and teachers to develop critical thinking, supports a culture of change, and moves from traditional to constructivist teaching and learning (Sawada et al., 2002).
7. *Student-centered instruction* – Instruction that gives the learner responsibility for gaining knowledge through active engagement in collaborative learning activities (Reigeluth et al., 2017). Students are learning by doing. Teachers are facilitating the learning process and helping students set attainable learning goals (Reigeluth et al., 2017).
8. *Student engagement (in mathematics)* – Students are actively involved in a mathematics lesson. The quality of their involvement in mathematics lessons is defined by their level of active participation (Talbert et al., 2019).
9. *Task-based learning* – Learning occurs through active engagement in an authentic, relevant task that makes connections from prior knowledge to new knowledge (Reigeluth et al., 2017).
10. *Teacher-centered instruction* – Students are passive learners; the teacher gives them the information directly (Reigeluth et al., 2017). The teacher typically imparts information to students through lectures, breaking down information into manageable chunks for students (Bishop et al., 2018).

CHAPTER TWO: LITERATURE REVIEW

Overview

A systematic review of the literature was conducted to explore the problem of high school math teachers' conceptions of teaching and learning and their implementation of SCL instructional practices. This chapter will present a review of the literature related to the topic. In the first section, cognitive constructivism, teachers' beliefs about mathematics teaching and learning, and self-efficacy will be discussed regarding implementation of SCL instructional practices. The following section is a synthesis of recent literature regarding SCL instructional practices, including SCL in mathematics classes, the benefits and constraints of implementing SCL in mathematics, teachers' beliefs about SCL, teacher PD, and implementation of SCL in math classes. A gap in the literature will be addressed, presenting a feasible need for the current study.

Theoretical Framework

The theories that guide this literature review on mathematics teachers' beliefs towards SCL and its impact on their use of SCL in the mathematics classroom are cognitive constructivism, theories of teachers' beliefs of teaching and learning, and self-efficacy. Cognitive constructivism is a fundamental theory of SCL and therefore is essential for this study. Teachers' self-efficacy and their beliefs about the teaching and learning processes may affect their classroom behaviors and actions, including their instructional approaches (Schoenfeld, 1998; Tschannen-Moran et al., 1998). These theories together make up a framework for understanding the relationship between teachers' conceptions of teaching and learning and their use of SCL practices in their classrooms.

Cognitive Constructivism

The main theory guiding this literature review is cognitive constructivism because it is fundamental to student-centered teaching and learning practices. Cognitive constructivism is a learning theory grounded in the belief that individuals construct knowledge through interactions with their environment (Vygotsky, 1978). This learning theory emphasizes the role of the learner as maintaining responsibility for their learning through interaction and collaboration with their peers. Student-centered approaches to learning cover each of these aspects, allowing students to collaborate with their peers and make decisions regarding their learning (Eronen & Kärnä, 2018). A premise of cognitive constructivism is active involvement in the learning process, which is the main principle of student-centered instruction.

Vygotsky (1978) suggested that internal development processes occur when learners interact and collaborate with their peers in their environment. Learning first occurs through interactions with other people, then internally. Situated within this theory is the idea of the zone of proximal development (ZPD). The ZPD is the point in a student's learning process where the student is still developing knowledge but has not mastered understanding (Vygotsky, 1978). Although the learner assumes more responsibility for their learning, Vygotsky suggested that learning that occurs in the ZPD should be fostered under the guidance of an adult or more capable peers. This is essential in SCL classrooms, because the role of the teacher in student-centered classrooms is to provide the necessary support for the learners throughout the learning process. Through constructivist teaching practices, students can gain a deeper understanding of concepts through reflection and sharing their learning experiences.

Student-centered classrooms are designed to meet the needs of individual learners. Bruner (1966) proposed that teachers have four elements in their instructional materials –

predisposition, structure, sequence, and reinforcement. In selecting a task or problem, the teacher should consider factors that motivate learners to undertake problem-solving (Bruner, 1966). Within the task, smaller chunks of content should be organized under a larger concept using sequencing to help the learner transform and transfer learning. Finally, the learning process should be reinforced at first with extrinsic rewards, but eventually with more intrinsic rewards such as satisfaction in problem-solving (Bruner, 1966). Actively involving students in this exploratory learning process may help students develop independence, collaboration skills, and motivation (Stapleton & Stefaniak, 2019). Stapleton and Stefaniak (2019) suggested that these four components initially identified by Bruner are still relevant today in designing instruction that allows students to discover new knowledge.

Eronen and Kärnä (2018) reiterated this process in their grounded theory study, identifying three essential elements of SCL in mathematics. SCL in mathematics should include technologies that are easy for students to use, students' understanding the purpose of SCL, and diverse problems (Eronen & Kärnä, 2018). First, technology tools are helpful for students to explore mathematics concepts. For students to use the technology tools to solve the task or problem, they must be easy to use so learning the tools do not overcome learning the concepts (Eronen & Kärnä, 2018). Second, communicating the rationale for SCL with students is situated in the constructivist perspective, where students maintain responsibility for their learning. Finally, the selection of diverse tasks follows the process of designing instructional materials as identified by Bruner (1966). Task-based learning is one approach to SCL frequently used in mathematics. In this approach, the teacher introduces a problem or issue to students, who then collaborate to explore a possible solution (Francom, 2017). The instructor provides guidance and helps activate prior knowledge; however, the lesson should include several key components to assist the learner successfully. The interconnectedness of these principles lays the framework for SCL mathematics. Cognitive constructivism is used as the theoretical framework to examine teachers' roles in guiding students through their explorative and collaborative learning.

Teachers' Beliefs

Teachers' beliefs, goals, and knowledge of teaching are essential in understanding their behaviors and actions in the classroom (Schoenfeld, 1998). As a theory of teaching-in-context, this theory about teachers' beliefs, goals, and knowledge aims to justify how and why teachers engage in behaviors while teaching (Schoenfeld, 1998). Schoenfeld (1998) described their theory of teaching-in-context in this way:

> [H]igh priority goals will be consistent with the teacher's high activation beliefs; the actions the teacher undertakes or decides to undertake will be consistent with those goals and beliefs; and the teacher's actions will draw upon related knowledge that has a high activation level. (p. 3)

In terms of student-centered instruction, if the teacher has high goals to implement SCL, they likely have beliefs about SCL, and thus, their actions regarding SCL are more likely to be consistent with their goals, beliefs, and knowledge.

Teachers' beliefs, goals, and knowledge of teaching have varying degrees to which they influence teacher actions. Their beliefs, goals, and knowledge are determining factors of what teachers do and why they do it (Schoenfeld, 1998). Schoenfeld (1998) suggested that the three concepts work together to determine the actions of the teacher. The actions a teacher takes are consistent with their high priority goals and beliefs, which requires use of knowledge at high activation levels. By understanding a teachers' goals, beliefs, and knowledge regarding an instructional approach, such as SCL, a teacher's actions can be better understood (Schoenfeld, 1998).

Within the theory of teaching-in-context, the beliefs that impact teachers' actions include beliefs about the subject matter, the learning process, the teaching process, roles of types of instruction, and particular groups of students (Schoenfeld, 1998). McLeod (1992) argued that beliefs and other elements of the affective domain, such as attitudes and emotion, are essential in mathematics education. McLeod declared that teachers' beliefs about instruction and teacher attributions are directly related to affective factors. In addition, teachers' beliefs about their students and how they learn, as well as the teachers' beliefs about self, curriculum, and pedagogy, also affect their actions in the classroom (Pajares, 1992). The earlier a belief is developed, the more difficult it is to change because developed beliefs affect and influence new information (Pajares, 1992). Thus, it is essential to understand math teachers' beliefs regarding SCL instructional practices to determine their likelihood of utilizing such pedagogies in their classrooms.

Understanding teachers' beliefs is complicated; systems of beliefs are a broad concept and under-developed (Leder, 2019; Pajares, 1992). Beliefs about how mathematics teaching and learning impacts student learning are still being explored (Leder, 2019). Leder (2019) stated that mathematics teachers' beliefs and emotions about the subject matter, students, and teaching and learning are relevant to understand the practices teachers' implement in their classrooms. Yurekli et al. (2020) found that teachers' beliefs about and implementation of connection-making practices could be predicted by the teachers' beliefs about their students. According to Leder (2019), there is still much to understand about the relationship between math teachers' beliefs and their teaching practices. In mathematics education, it is essential that teachers' beliefs about teaching and learning are considered to understand their actions in their classrooms towards implementing SCL practices.

Teacher Self-Efficacy

Self-efficacy is a sub-construct of beliefs (Pajares, 1992). Self-efficacy theory plays an essential role in understanding teachers' implementation of specific instructional practices. Self-efficacy involves one's belief in successfully performing a task to achieve a particular outcome (Bandura, 1977). This personal belief of whether one can accomplish a task or not can either enhance or hinder their learning (Bandura, 2001). According to Bandura (1977), "[E]fficacy expectations determine how much effort people will expend and how long they will persist" (p. 194). That is, teachers are more likely to sustain the execution of instructional practices that they believe they can successfully implement.

Within the theory of self-efficacy, Bandura (1977) identified dimensions and sources of a person's efficacy expectations. Efficacy expectations differ in magnitude, generality, and strength (Bandura, 1977). Magnitude refers to the ordered level of difficulty of a task, such as simple, moderate, or challenging, while an individual's expectations of performing the task can range from weak to strong (Bandura, 1977). Together, the levels of the dimensions determine the efficacy expectations of performing a task. In addition to the dimensions of efficacy expectations, Bandura identified the sources of personal efficacy as "performance accomplishments, vicarious experience, verbal persuasion, and physiological states" (p. 195). Together, these sources and dimensions of efficacy determine a person's perceived self-efficacy to accomplish a specific task. Therefore, to understand a teacher's ability to implement SCL instructional practices, it is essential to understand their personal beliefs about adopting new or different instructional approaches.

Teacher efficacy refers to a teacher's belief in their ability to plan and carry out a particular instructional task (Tschannen-Moran et al., 1998). More experienced teachers tend to develop a stronger sense of teacher efficacy; however, new changes such as instructional practices may negatively affect teacher efficacy (Tschannen-Moran et al., 1998). Teachers who typically utilize traditional instructional methods may have lower self-efficacy when using reformed teaching, including SCL. Teachers with higher self-efficacy may be more likely to implement new instructional practices, such as SCL (Corkin et al., 2019). Thus, teacher self-efficacy is essential in understanding the relationship between teachers' conceptions of teaching and learning and their use of SCL practices in math classes.

There are two dimensions of teacher efficacy—one is personal teaching efficacy, which is a teacher's personal feeling of competence as a teacher (Tschannen-Moran et al., 1998). Tschannen-Moran et al. (1998) identified the second dimension as the "teaching task and its context" (p. 228), or, factors that affect the difficulty levels of teaching and resources available to simplify learning. Together, these dimensions influence the teacher's efficacy to successfully undertake a teaching task, which is related to the effort placed on the task (Tschannen-Moran et al., 1998). Teacher efficacy is cyclical with relation to effort and performance. "Greater efficacy leads to greater effort and persistence, which leads to better performance, which in turn leads to greater efficacy" (Tschannen-Moran et al., 1998, p. 234). This idea is also true of lower efficacy, which leads to lower effort and results in poor teaching outcomes, which decreases efficacy.

Helping teachers succeed when implementing changes in the classroom can work to change teachers' beliefs (Guskey, 2002). Teachers' attitudes and beliefs may change when teachers receive feedback and support that their implementation of new instructional practices has resulted in success (Guskey, 2002). Emery et al. (2021) proposed that developing teacher self-efficacy earlier through PD may support the use of SCL. Guskey (2002) stated that for a new instructional approach to be implemented properly, it must become part of the teacher's routine. Thus, to sustain implementation of SCL approaches, teachers must believe that they can successfully implement them in their classrooms.

Constructivism and teachers' beliefs of teaching and learning, including their self-efficacy, are the driving theories behind this study and literature review. At the root of student-centered mathematics instruction is constructivism. SCL approaches to teaching mathematics differ greatly from traditional teaching and learning, and thus command a reason for understanding teachers' beliefs about different instructional approaches. For a teacher to transition from direct instruction to SCL requires a significant shift in teaching practices. Thus, further understanding of a teachers' conceptions of teaching and learning is warranted. Within the system of a teachers' beliefs regarding teaching and learning, the teacher has a level of self-efficacy which drives their beliefs in their ability to implement new, SCL instructional techniques. Therefore, these theories are essential to understanding the relationship between teachers' conceptions of teaching and learning and their practical use of SCL instruction.

Related Literature

Historically, mathematics at the secondary level was taught using traditional learning experiences, such as teacher-directed instruction (Wilkie, 2019). In mathematics, this learning looks like the teacher lecturing, giving students information about a topic or a set of rules or procedures which they are expected to memorize. However, the National Council of Teachers of Mathematics (NCTM) refers to such traditional learning practices as unproductive (NCTM, 2014). In the face of reform-based mathematics education, one problem for math educators is that parents, students, and other educators believe this counterproductive method is how mathematics should be taught (NCTM, 2014). Schoenfeld (2004) called this belief a “naïve view” that, while may be a sensible method, lacks powerful learning (p. 262). This declaration is still relevant in the United States as research has indicated that students show higher achievement and higher engagement in student-centered mathematics classes (Bishop et al., 2018; Eronen & Kärnä, 2018; Jamaan et al., 2020; Talbert et al., 2019).

More productive approaches to learning mathematics are problem-solving, reasoning, discourse, exploration, and varied approaches, solutions, and strategies (NCTM, 2014). However, recent research has indicated that factors such as teachers’ self-efficacy, identity, and teaching beliefs may impact their use of these more student-centered approaches to teaching and learning (Corkin et al., 2019; Davis et al., 2020; Emery et al., 2021; Keiler, 2018). For example, some K-12 math teachers in Texas indicated that they believed students learn best from step-by-step instruction and repeated practice, which is inconsistent with the reformed math movement (Corkin et al., 2019). In the same study, some teachers noted a lack of confidence and lack of interest in trying new, student-centered approaches to teaching (Corkin et al., 2019). Additionally, Davis et al. (2020) found that teachers who tended to have more traditional teaching beliefs used fewer student-centered practices, whereas teachers with more constructivist views used more student-centered practices. Similarly, Emery et al. (2021) concluded that teachers’ self-efficacy strongly influenced their teaching practices. As teachers transition from using more traditional teaching approaches to student-centered approaches, they may experience identity transformations as they embrace their new roles in SCL approaches (Keiler, 2018).

When the reform-based math movement was implemented, teachers were expected to change their teaching with little support (Schoenfeld, 2004). Research has indicated that teachers need support when implementing student-centered teaching and learning mathematics (Hayward

& Laursen, 2018; Heyd-Metzuyanim, 2019; Liu & Phelps, 2020; Wilkie, 2019). Math instructors in a training program for implementing inquiry-based instructional practices reported feeling supported by department chairs and colleagues, as well as from an online support community (Hayward & Laursen, 2018). Liu and Phelps (2020) concluded that school programs that provide follow-up support give teachers opportunity to process and implement strategies learned during PD. Support for teachers should also include observations, followed by conversations about the lesson, so teachers can process the use of new instructional techniques (Heyd-Metzuyanim, 2019). Therefore, teachers are much more likely to succeed in implementing SCL practices when educational institutions provide teachers with support.

Student-Centered Learning

The literature suggests that features of student-centered instruction improve learning and levels of student engagement. SCL is a constructivist approach to teaching and learning involving students as active participants in their learning experiences. This approach to teaching and learning is in opposition to traditional direct instruction. In SCL, the roles of teachers and students change significantly compared to traditional teaching and learning approaches (Keiler, 2018). One of the significant differences is that the role of the teacher is to focus on what the students are doing to interact with the content and their peers instead of the teacher delivering the content to passive listeners (Eronen & Kärnä, 2018; Keiler, 2018). Within that change, it should be noted that the role of the student changes from passive listener to actively engaged in exploration, tasks, and discourse.

The roles of teachers and students change when instructional practices change from traditional to constructivist, or student-centered. The students are more actively involved in their learning processes, which may be more beneficial to students, as indicated by recent research

(Eronen & Kärnä, 2018; Jamaan et al., 2020; Keiler, 2018; Morrison et al., 2021; Moyer et al., 2018; Talbert et al., 2019). Talbert et al. (2019) concluded that SCL had a positive effect on student engagement compared to teacher-centered learning for the middle and high school math students in their study. Other studies determined that students became more independent learners and were able to collaborate with their peers to accomplish learning tasks (Eronen & Kärnä, 2018; Morrison et al., 2021; Moyer et al., 2018). Through the use of exploration-based lessons in middle school, students were able to learn more independently and with their peers than students in a non-SCL-based class (Eronen & Kärnä, 2018).

Research has indicated that SCL helps students become more independent learners who rely less on their teacher (Eronen & Kärnä, 2018; Morrison et al., 2021; Moyer et al., 2018). Morrison et al. (2021) determined that teachers and students in a project-based high school developed strong personal connections, with the teachers' role as motivator and facilitator. In a causal comparison study, teachers in the learner-centered instruction experimental group were significantly higher than the non-learner-centered control group on facilitating student learning, empowering learners, and motivating learners (Cheng & Ding, 2021). However, in a study of the effects of reform in Ireland, a comparison of students' scores on college algebra exam pre-reform compared to students' post-reform indicated a decline in performance (Prendergast & Treacy, 2018). The teacher participants in this study indicated lack of preparedness and confidence implementing the reform-based practices (Prendergast & Treacy, 2018). The benefits of utilizing SCL practices in reformed mathematics classes warrant further investigation.

Student-Centered Learning in Mathematics

In the United States, since the implementation of the Common Core State Standards for Mathematics, math teachers are expected to utilize reform-based teaching and learning practices.

The reform-based practices are grounded in constructivist principles, and most are considered student-centered (Moyer et al., 2018). Some student-centered approaches to teaching and learning mathematics include task-based learning (Klein & Leikin, 2020), problem-based learning (Eronen & Kärnä, 2018; Jamaan et al., 2020), and inquiry-based learning (Hayward & Laursen, 2018). Each approach consists of student-centered principles but is designed to cognitively challenge students differently.

Task-based Learning. Task-based learning involves students actively and collaboratively solving tasks based on real-world situations (Francom, 2017). The tasks chosen must be designed to enable student collaboration and communication, and thus cannot be procedural in nature (Shuilleabhain & Seery, 2018). Eronen and Kärnä (2018) added that authentic tasks that require students to explore new concepts are an essential element of task-based learning. That is, the tasks should be nonroutine. Klein and Leikin (2020) identified four types of open mathematical tasks—multiple strategies, multiple outcomes, investigative, and sorting. Multiple strategy tasks have multiple starting points and multiple outcome tasks have different possible solutions, whereas investigative tasks and sorting tasks are both open-start and open-end (Klein & Leikin, 2020). The type of task may be dependent upon the concept being taught.

Some of the literature has indicated that teachers and students can identify the benefits of task-based learning (Eronen & Kärnä, 2018). Eronen and Kärnä (2018) found that Finnish high school math students, over time, preferred to work collaboratively on tasks. In addition, through a lesson study, high school teachers in Ireland noticed the benefits of students communicating their thought processes, such as building conceptual understanding and developing mathematical reasoning skills (Shuilleabhain & Seery, 2018). However, Klein and Leikin (2020) concluded that teachers in their study were less likely to implement open tasks if they believed students would have difficulty solving them. From this literature, it may seem that students and teachers notice the benefits of task-based learning. However, teachers may have reservations regarding implementation, thus warranting further investigation. In addition, teachers need some support or professional learning on how to appropriately implement task-based learning. According to Wilkie (2019), algebra teachers may attempt to guide students through the task before letting them explore, which contradicts the purpose of task-based instruction.

Problem-based learning. Similar to task-based learning, problem-based learning (PBL) is a collaborative approach to learning through problem-solving. Task-based learning typically occurs over one lesson, whereas PBL occurs over more extended periods, such as a unit or an academic term (Francom, 2017). Additionally, PBL is less structured than task-based learning, where the teacher can scaffold learning during the task. Research has shown the benefits of PBL on student learning to include freedom of learning, increased achievement outcomes, and deeper thinking skills that are transferable outside the classroom (Craig & Marshall, 2019; Jamaan et al., 2020; Lee & Blanchard, 2019; Morrison et al., 2021).

In a causal-comparison study, geometry students who used PBL to explore new concepts had higher achievement outcomes than students enrolled in the same course but learning by methods directed by the teacher (Jamaan et al., 2020). Science, technology, engineering, and mathematics (STEM) students in a PBL high school reported sense of independence while learning and having critical thinking skills (Morrison et al., 2021). The students in this study also reported feeling challenged and supported by their teachers (Morrison et al., 2021). Craig and Marshall (2019) found no significant increase in math students' standardized test scores after PBL instruction; however, that study was not designed to examine other benefits of using PBL in math and science, such as student engagement or student autonomy in learning. One reason for this finding may be that standardized math tests typically assess at the lower-level and not the higher-level thinking skills that PBL develops within learners (Craig & Marshall, 2019).

Benefits of problem-based learning in the classroom also apply to the teachers. Lee and Blanchard (2019) concluded that secondary teachers who implement PBL feel more competent, have higher expectations of success, and have more substantial interest and beliefs toward PBL than teachers who do not use PBL. Cheng and Ding (2021) suggested that teachers who use learner-centered instruction function better when implementing PBL and project-based learning than those who do not utilize SCL. Teachers who implement PBL have had some training on integrating PBL in their classes (Craig & Marshall, 2019; Lee & Blanchard, 2019). For teachers to successfully implement PBL, it may be beneficial to have training and support before and during the transition. According to Owens et al. (2018), STEM teachers reported problem-based learning as a topic of interest for PD. Although the teachers in these studies have had training on PBL, it remains unclear how their beliefs about teaching and learning may impact their use of PBL.

Inquiry-based learning. Inquiry-based learning (IBL) is another student-centered approach to learning mathematics similar to task-based learning and PBL. Like the other two approaches, IBL actively engages students in collaboration; however, the tasks are more designed around discussion and exploration to build conceptual understanding (Zvoch et al., 2021). Research has indicated that teachers and students benefit from the student-centered approach of inquiry-based learning (Huang et al., 2021; Keiler, 2018; Moyer et al., 2018; Zvoch et al., 2021). Moyer et al. (2018) showed that high school students in an inquiry-based program tended to have a more positive view of mathematics than students not in the program.

Students' conceptual understanding of density improved from pre- to post-test in a middle school science lesson following an inquiry-based lesson (Zvoch et al., 2021). However, the authors did not determine a significant difference between students in the inquiry-based class and students in the direct instruction class (Zvoch et al., 2021). In a program where students were responsible for guiding their peers during inquiry learning, teachers became more open to allowing students to lead mathematical discussions (Keiler, 2018). Additionally, secondary school math students in Beijing reported IBL experiences that involved more student discussions and explanations of ideas (Huang et al., 2021). Therefore, although the research has indicated IBL does not necessarily make substantial differences in achievement compared to direct instruction, students are more likely to engage in mathematical discussion and reasoning and teachers are more likely to incorporate student-led discussions with this approach.

Student-Centered Learning and Student Achievement

The literature previously discussed has shown benefits of SCL in mathematics, such as the positive impact on student perspective of math and increased student collaboration and communication. However, some research on SCL in mathematics has also shown an increase in student achievement (Bishop et al., 2018; Jamaan et al., 2020). Bishop et al. (2018) found that college students enrolled in a developmental math course had higher course success rates with SCL than those enrolled in the same class with direct instruction. In a study of Indonesian geometry students, problem-based learning showed higher scores on geometry learning outcomes than students who learned from the scientific learning approach, which involved teacher-led instruction (Jamaan et al., 2020).

Although some research has indicated higher success from SCL than teacher-directed learning, other research has shown no significant differences (Craig & Marshall, 2019; Zvoch et al., 2021). In a study of Texas high school math and science PBL students, Craig and Marshall (2019) found no significant difference in math achievement on the state exam from ninth to eleventh grade compared to the control group. However, the authors did report findings of significantly higher science scores from students in PBL compared to the control group (Craig & Marshall, 2019). Additionally, middle school science students in IBL showed no significant differences in post-achievement compared to students receiving direct instruction (Zvoch et al., 2021). However, the inquiry-based students in this study were more likely to reach highly proficient status than direct instruction students (Zvoch et al., 2021).

Teachers and students benefit from the use of SCL in mathematics classes (Cheng & Ding, 2021; Keiler, 2018; Morrison et al., 2021). The benefits of SCL in mathematics classes involve more than performance achievement. For example, in a qualitative study of teachers and students from a PBL-based high school, students reported that use of student-centered projects helped them improve skills and develop interactions with peers (Morrison et al., 2021). Cheng and Ding (2021) reported that students in the learner-centered experimental group had significantly higher intrinsic motivation that those in the traditional group. Additionally, teachers in the learner-centered group had significantly higher mean scores on facilitating learning, supportive assessment such as peer-evaluation and self-reflection, and empowering students to take ownership of their learning than the traditional instruction group (Cheng & Ding, 2021). In another study, teachers who switched from traditional learning to SCL also made positive comments about a shift in their teaching identity after using SCL that included becoming more of a facilitator, motivator, and content resource rather than content provider (Keiler, 2018).

Although the literature on student achievement through SCL is conflicting, there is some evidence of learning gains through SCL and increased student engagement (Bishop et al., 2018;

Jamaan et al., 2020; Talbert et al., 2019). The literature discussed that showed no significant differences in student achievement did not address teachers' perceptions of SCL or level of preparedness to implement. Other literature has indicated that some teachers have challenges adapting to SCL practices, such as time constraints and perceived student ability (Akhter et al., 2018; Corkin et al., 2019; Davis et al., 2020; Xie & Cai, 2020). Therefore, it is essential to identify teachers' conceptions regarding SCL and ways to support these teachers as they transition from traditional to student-centered instructional practices.

High School Math Teachers Beliefs About Student-Centered Learning

High school math teachers are transitioning to more student-centered practices for teaching and learning for various reasons. Some education agencies call for more SCL in mathematics classes (Bishop et al., 2018; McPherson, 2021; Valoyes-Chávez, 2019). Others implement SCL practices because of their teaching beliefs and philosophies (Berger & Lê Van, 2019; Davis et al., 2020; Shuilleabhain & Seery, 2018). Most teachers are familiar with SCL approaches to teaching mathematics but may not frequently implement the practices (Davis et al., 2020; Yurekli et al., 2020). High school teachers with progressive educational beliefs also tended to have constructivist teaching and learning conceptions (Yalcin İncik, 2018). Conversely, Corkin et al. (2019) found that K-12 in-service math teachers in Texas struggled to describe a constructivist teaching philosophy but did describe using activities consistent with SCL. In a mixed methods study of pre-service and in-service teachers in Columbia, one of the three in-service participants reported constructivist views of teaching mathematics on questionnaires, but an analysis of lesson plans indicated use of traditional teaching approaches (Vesga-Bravo et al., 2022). The literature also indicated that the frequency to which math teachers implement SCL varies for a variety of reasons, including their teaching beliefs, teacher self-efficacy, and barriers to implementation (Berger & Lê Van, 2019; Corkin et al., 2019; Davis et al., 2020; Yurekli et al., 2020).

Teachers' Beliefs

Dejene (2020) and Yang et al. (2020) found that teachers' beliefs about teaching and learning may impact how often they implement SCL in their classrooms. These beliefs can positively or negatively impact the frequency of use of SCL practices in mathematics classes. A case study of teachers in different content areas found that the beliefs teachers held about teaching and learning prior to SCL PD influenced how they perceived their SCL experience (Dunbar & Yadav, 2022). Teachers typically hold either a constructivist view of teaching mathematics or a traditionalist view (Vesga-Bravo et al., 2022). Among eight pre-service and in-service math teachers in Columbia, all but one self-reported constructivist beliefs of math teaching and learning (Vesga-Bravo et al., 2022). However, in semi-structured interviews, only five of these teachers indicated constructivist beliefs (Vesga-Bravo et al., 2022). Pre-service teachers enrolled in a graduate program tended to have traditional conceptions of teaching and learning (Dejene, 2020). The traditional conceptions of the teachers in the study were positively correlated with their preferred instructional approaches, which also tended to be traditional (Dejene, 2020). Conversely, Chinese pre-service math teachers with dynamic math beliefs and constructivist pedagogical beliefs predicted their self-reported inquiry-oriented instructional practices (Yang et al., 2020). However, Yurekli et al. (2020) found that, although math teachers had positive beliefs regarding reformed teaching practices, they did not always report implementing the approaches which they believed to be important.

Teachers' lack of confidence regarding student-centered practices may negatively impact their implementation of SCL (Akhter et al., 2018; Klein & Leikin, 2020; Yurekli et al., 2020). In their study, Klein and Leikin (2020) found a negative association between math teachers' conceptions of students' ability to solve tasks and the teachers' confidence to implement the tasks. Elementary teachers in Pakistan who perceived their students' ability to learn challenging math concepts as low were less likely to report using SCL approaches for those concepts (Akhter et al., 2018). Teachers who believe that students will struggle with independently learning math concepts may be less likely to implement SCL strategies. However, Yurekli et al. (2020) concluded that teachers in their study typically held positive beliefs about utilizing practices that promote conceptual understanding, which is an essential aspect of SCL. Research has demonstrated that years of experience and changes in identity related to changes in instructional practices may account for some more positive beliefs towards SCL (Keiler, 2018; Wilkie, 2019; Xie & Cai, 2020).

Teaching Experience. Some literature has suggested that teachers' beliefs regarding teaching and learning mathematics may depend on their teaching and learning experiences (Klein & Leikin, 2020; Xie & Cai, 2020). Teachers with more experience using SCL techniques, such as task-based learning, PBL, and IBL, tend to have more confidence in implementing those approaches in their classrooms (Hayward & Laursen, 2018; Klein & Leikin, 2020; Lee & Blanchard, 2019). In a study of pre-service math teachers in China, Yang et al. (2020) found that teachers who had more dynamic views of teaching mathematics were more likely to utilize IBL in their math classes. In contrast, a case study of pre-service teachers in middle school STEM classes taught through SCL approaches found all but two of the 13 participants de-valued the project-based learning program because of its lesser focus on standards and content-based learning (Scogin et al., 2022). Xie and Cai (2020) concluded in their study of high school math teachers in China that longer teaching experience did not imply teachers held constructivist views of teaching and learning. In fact, teachers with more than 20 years of experience were more likely to agree that teaching mathematics is a transmission of knowledge when compared to teachers with less experience (Xie & Cai, 2020). This belief is in opposition to the principles of SCL and is more consistent with traditional teaching. It is important to note that teachers with experience using SCL practices tend to have stronger beliefs regarding SCL. Therefore, teachers transitioning from direct instruction to SCL approaches may benefit from peer or coach support (Corkin et al., 2019; Lee & Blanchard, 2019; Wilkie, 2019).

Changes in Teacher Identity. Researchers have agreed that changing teachers' identities and practices is time-consuming and ongoing (Heyd-Metzuyanim, 2019; McPherson, 2021; Valoyes-Chávez, 2019). However, teachers willing to attempt new teaching practices such as SCL are likely to experience a change in teacher identity (Keiler, 2018; McPherson, 2021; Wilkie, 2019). Keiler (2018) determined that identity changes of secondary teachers in their study included a gain in insight about individual students and more substantial effects in adopting SCL practices. Teachers' lack of familiarity regarding constructivist pedagogies may impact teachers' beliefs about their classroom practices (Heyd-Metzuyanim, 2019).

The degree to which teacher identity changes may be impacted by the level of support they receive regarding changes in teaching practices (McPherson, 2021; Valoyes-Chávez, 2019; Wilkie, 2019). Depending on the school expectations, math teachers are expected to carry out multiple roles, such as a director or a facilitator, which may impact a teacher's identity if not made clear by school administration (Valoyes-Chávez, 2019). In one case study, the teacher under study developed a deeper understanding of constructivist pedagogies through support from a teacher-leader and the principal, and thus was able to identify and align to a set of pedagogies (Heyd-Metzuyanim, 2019). If teachers perceive support from the school or district personnel, they may be more likely to experiment with new teaching practices. New teaching practices are shown to impact changes in teacher identity (Keiler, 2018; McPherson, 2021). Teachers' beliefs about the new approaches and their impact on using them in the classroom warrants further examination.

Teacher Self-Efficacy

Recent literature has confirmed that higher teacher self-efficacy positively influences teachers' use of instructional approaches, such as SCL (Emery et al., 2021; Thurm & Barzel, 2020). For university STEM faculty in the United States, self-efficacy in teaching strongly influenced biology faculty's learner-centered teaching practices (Emery et al., 2021). Faculty trained in student-centered STEM practices tended to have higher self-efficacy than faculty who did not (Emery et al., 2021). Thurm and Barzel (2020) found that mathematics teachers' self-efficacy increased after participating in PD which involved learning how to teach multiple representations using technology. After being trained in and implementing a student-centered approach to teaching math, one teacher experienced increased feelings of self-efficacy reportedly due the level of confidence that students are engaged in mathematics discussion (Keiler, 2018). These findings echo other studies indicating that pre-service and in-service math teachers with higher self-efficacy may attempt new instructional approaches in line with constructivist principles (Corkin et al., 2019; Lau, 2021). Berger and Lê Van (2019) concluded that self-efficacy is part of a teacher's core identity, which is also comprised of commitment to teaching, aptitude, and social utility value. The relationship between teachers' beliefs and the frequent use of constructivist teaching approaches may justify further investigation on how beliefs impact the implementation of SCL practices.

Higher or increased levels of self-efficacy do not necessarily indicate a willingness to change instructional practices. In a case study of secondary math teachers in Australia, one teacher with apparently high self-efficacy towards teaching mathematics would not change her approaches to teaching algebra, despite being trained in new methods (Wilkie, 2019). This finding is consistent with the findings of Xie and Cai (2020) that indicated that math teachers with more than 21 years of teaching experience tend to believe that students need repeated practice and memorization. This belief is a contrast to SCL practices and more in line with traditional views of teaching mathematics. Therefore, teachers may have high self-efficacy towards teaching mathematics or trying new practices, but their beliefs in how mathematics should be taught may be more consistent with traditional teaching practices than constructivist.

Constraints to Implementing Student-Centered Learning

Besides teachers' teaching and learning beliefs and their teaching self-efficacy, the literature illustrated other barriers to implementing SCL (Akhter et al., 2018; Corkin et al., 2019; Yurekli et al., 2020). Some studies suggested that time is a constraint due to additional preparation and planning and time to implement (Akhter et al., 2018; Corkin et al., 2019; Emery et al., 2021). In Pakistan, elementary math teachers indicated that they do not have enough time to plan or prepare for SCL approaches (Akhter et al., 2018). Similarly, teachers who transitioned to SCL in middle and high schools in Idaho identified the time to develop and implement SCL activities as a challenge (McPherson, 2021). K-12 in-service math teachers in urban Texas schools indicated that developing deep understanding is time-consuming and that there is limited instructional time in the school year to meet pacing requirements (Corkin et al., 2019). In each of these studies, teachers understood the principles of SCL but did not perceive that there was enough time to plan for and implement SCL practices. Similarly, teachers in a case study reported that strict pacing to cover standards and testing restricts efforts to implement PBL, especially with little support from school or district administration (Dunbar & Yadav, 2022).

Additionally, teachers' perceptions of their students may hinder SCL use in their math classes (Corkin et al., 2019; Yurekli et al., 2020). Yurekli et al. (2020) concluded that teachers in grades four through eight revealed student backgrounds as one of the significant constraints on implementing SCL. Similarly, the teachers in urban Texas schools cited students' basic needs not being met, rough home life, and student background as challenges to implementing SCL (Corkin et al., 2019). Low-achieving students in Beijing and Netherlands reported using less IBL, whereas higher achieving students reported more frequent use (Huang et al., 2021). This finding may suggest that teachers may be more likely to use more student-centered practices with higher achieving students. Based on the findings of the literature discussed, teachers may have positive conceptions of SCL practices but may be hesitant to implement them because of the constraints faced, such as time involved to plan and implement and perceived student ability.

Professional Development for Student-Centered Learning

Teachers may be more likely to utilize SCL approaches if provided appropriate support through PD opportunities (Copur-Gencturk & Papakonstantinou, 2016; Dunbar & Yadav, 2022; Hayward & Laursen, 2018; Owens et al., 2018). Math teachers who receive professional training on student-centered practices may implement them more frequently in their classrooms (Copur-Gencturk & Papakonstantinou, 2016; Corkin et al., 2019; Hayward & Laursen, 2018). Recent research has suggested that allowing teachers to make decisions regarding their PD choices and instructional practices may be beneficial for implementing new approaches (Corkin et al., 2019; Dunbar & Yadav, 2022; Owens et al., 2018; Shuilleabhain & Seery, 2018). Dunbar and Yadav (2022) concluded from their case study that teachers may benefit from experimenting with new pedagogy, such as PBL, before adopting new practices. Some STEM teachers have indicated preferences of professional training to include aspects of SCL, such as problem-based learning (Owens et al., 2018). Shuilleabhain and Seery (2018) suggested that teachers who voluntarily participate in PD may be more likely to try new practices.

PD for math teachers implementing SCL practices should also incorporate ongoing support to sustain changes in the classroom (Copur-Gencturk & Papakonstantinou, 2016; Hayward & Laursen, 2018; Liu & Phelps, 2020). Liu and Phelps (2020) concluded that math teachers in Texas had an average knowledge decay rate of 37 days following PD. Implications from this study indicate that follow-up activities, including follow-up support, may help teachers sustain knowledge gained from PD. Heyd-Metzuyanim (2019) suggested that when teachers are implementing new instructional practices, their classes should be observed with open dialogue regarding the instructional practices used. College math instructors who received online support following IBL PD reported continued use of the practices one year later (Hayward & Laursen, 2018). In Ireland, math teachers showed increased efficacy in implementing new constructivist pedagogies after participating in cycles of a collaborative lesson study (Shuilleabhain & Seery, 2018). Therefore, math teachers who willingly participate in PD for SCL practices may sustain these learning approaches in their math classes. Teachers may have strong conceptions of constructivist teaching but may not implement SCL in their classes, thus justifying further investigation.

Features of Effective PD for Student-Centered Math Practices

Different features of teacher PD may impact teachers' beliefs regarding changed curriculum and implementing SCL instructional practices (Heck et al., 2019; Owens et al., 2018; Thurm & Barzel, 2020). For example, elementary math teachers in one study were assigned to one of three types of professional learning experiences, which were a face-to-face facilitated workshop, a multimedia course, or through curriculum materials including student work examples (Heck et al., 2019). Although none of the three formats were more effective than the others, teachers in all three showed improvements in their instructional practices using context to teach early algebra concepts (Heck et al., 2019). It is important to note that teachers who are used to traditional pedagogies not only need to learn the new instructional practice, but they must also unlearn the old ones (Heyd-Metzuyanim, 2019). It has been recommended that effective teacher PD consider the following aspects: collective participation, content knowledge, learner-centered activities, and program duration with follow-up support (Desimone et al., 2002; Guskey, 2002; Hill & Ball, 2004; Kennedy, 2016).

Different aspects of teacher PD are important for math teachers, such as the structure, time to learn, and content of the PD (Owens et al., 2018; Thurm & Barzel, 2020). According to Owens et al. (2018), teachers preferred half-day or full-day face-to-face workshops in their district, but also want access to ready-to-use materials and time to learn from their peers. Thurm and Barzel (2020) suggested that face-to-face PD throughout the school year may have a positive impact on teachers' beliefs regarding using technology to teach multiple representations in mathematics. In their study, the PD occurred over four sessions with time between for teachers to implement the strategies and reflect on their practices (Thurm & Barzel, 2020). Similarly, another study aimed to investigate the effects of PD on secondary teachers' mathematics pedagogical technology knowledge (MPKT) using dynamic math tools to teach (Clark-Wilson & Hoyles, 2019). The authors utilized a lesson study approach—teachers participated in a one-day session, implemented strategies in their classes, then returned for reflection (Clark-Wilson & Hoyles, 2019). Although the teachers lacked confidence, according to Clark-Wilson and Hoyles

(2019), teachers reported seeing the value in teaching with the dynamic math tools. Based on the results of their study, Lee and Vongkulluksn (2023) recommended providing teachers with continuous opportunities that allow them to reflect on the practices they learn in PD to shape student outcomes. The findings in these studies incorporated key features of PD that improved teaching, such as focusing on content knowledge and collective participation (Kennedy, 2016). Clark-Wilson and Hoyles recommended focusing PD activities on the planning, teaching, and reflection of instructional activities that promote rethinking and extending previously learned mathematics ideas.

Ongoing Support for Teachers

Recent literature has indicated that program duration is an essential feature for teacher PD to ensure sustainability of program content (Byrne & Prendergast, 2020; Horn et al., 2020; Russell et al., 2020). According to Byrne and Prendergast (2020), secondary math teachers in Ireland that used a reformed curriculum indicated the need and want for continuous PD on implementing the curriculum in their classes. Another study found that elementary math teachers involved in in-depth coaching sessions throughout the school year utilized reformed practices in their classrooms, such as building students’ conceptual understanding and advanced questioning (Russell et al., 2020). Additionally, Horn et al. (2020) indicated that schools should cultivate high-depth meetings involving teacher collaboration throughout the school year for professional learning to be meaningful. Based on the findings of these studies, instructional coaching and professional learning communities may increase teachers’ implementation of SCL instructional practices.

Instructional Coaching. One type of PD discussed in the literature to support mathematics teachers’ implementation of SCL instructional practices is instructional coaching

(Horn et al., 2020; Keiler, 2018; Russell et al., 2020). Keiler (2018) concluded that teachers who received coaching that included modeled lessons, guidance, and encouragement made significant progress in their teaching transformations incorporating SCL. Similarly, Russell et al. (2020) found that third through eighth grade teachers with a coach showed high rates of growth in depth and specificity of conceptual understanding. The teachers in this study engaged in deep and specific conversations that focused on interactions between teachers, students, and mathematics and improved their approaches to develop students' conceptual understanding by giving students more opportunities with high level math tasks (Russell et al., 2020). Features of instructional coaching that are beneficial to teachers implementing SCL instructional practices include high-depth conversations with colleagues, collaboration in lesson planning, and conceptually rich conversations (Horn et al., 2020; Russell et al., 2020).

Professional Learning Networks. As previously noted, teachers are likely to seek advice and learn from colleagues with similarities (Horn et al., 2020). Thus, research on professional learning networks has shown to impact discussions among math teachers regarding involvement in pedagogy and content (Larsen & Parrish, 2019; Matranga & Silverman, 2022). Professional learning can occur in person or online; this is also true of teacher networks. In person, Horn et al. (2020) reported that math teachers who participated in high-depth conversations about mathematical knowledge for teaching with peers increased their discussions about pedagogy and content. Math teachers involved in online PD with community discussion boards to support their reasoning about functions improved their discourse and collaboration, indicating community-building (Matranga & Silverman, 2022). Some math teachers utilized social media (Twitter, Facebook, Pinterest, etc.) to make connections with like-minded peers who share resources aligned with their pedagogies, which were centered around reform-based approaches (Larsen & Parrish, 2019). Therefore, developing a professional learning network with other math teachers may help support teachers' implementation of SCL practices.

Implementing Student-Centered Learning Strategies

Previous sections discussed the benefits of SCL on student achievement, teachers' beliefs, self-efficacy, perceived constraints to implementing SCL, and PD that prepares teachers to use SCL. Teachers' perceived value of SCL and self-efficacy may be a considerable factor as to why and how teachers implement SCL practices (Lee & Blanchard, 2019; McPherson, 2021). Some studies have shown that teachers find success sustaining implementation of student-centered practices with support from colleagues or instructional coaches (Cheng & Ding, 2021; Copur-Gencturk & Papakonstantinou, 2016; Hayward & Laursen, 2018; Shuilleabhain & Seery, 2018). However, teachers found more success implementing SCL in a school where administration supported innovative teaching methods, such as SCL (Cheng & Ding, 2021). Yet some research has indicated that teachers either may not sustain SCL practices or may have difficulties launching them in their classrooms because of their perceptions of the strategies (Prendergast & Treacy, 2018; Valoyes-Chávez, 2019; Wilkie, 2019). Teachers' beliefs about teaching and learning and their self-efficacy towards implementing SCL may be a factor in the frequency with which they use SCL in their mathematics classes.

A teachers' beliefs about teaching and learning impacts their classroom practices (Prendergast & Treacy, 2018; Xie & Cai, 2020; Yang et al., 2020; Yurekli et al., 2020). Chinese pre-service mathematics teachers' beliefs about the dynamic nature of mathematics and their constructivist pedagogical beliefs were positively associated with their self-reported use of inquiry-oriented instructional practices (Yang et al., 2020). In-service teachers in Colombia who reported constructivist beliefs of mathematics teaching and learning also utilized constructivist practices in their classroom lesson plans (Vesga-Bravo et al., 2022). Yurekli et al. (2020) found that teachers had positive beliefs regarding students learning mathematics through reformed practices, including building conceptual understanding using multiple representations. However, teachers in this study also report constraints on implementation, such as limited time, class size, and lack of support (Yurekli et al., 2020). In their study of middle school math teachers, Lee and Vongkulluksn (2023) found that teachers' epistemological beliefs could positively and significantly predict how often the teachers used strategies that engaged math students in constructivist learning approaches. In other studies, researchers found that teachers valued static mathematics learning approaches, such as procedure-based algebra and drilling math skills, and did not want to neglect such methods of learning by using SCL (Prendergast & Treacy, 2018; Xie & Cai, 2020). Thus, it is essential for schools to foster collaboration and support for teachers implementing new student-centered pedagogies.

As previously discussed, teachers implementing new instructional approaches benefit from collective participation and collaboration (Hayward & Laursen, 2018; Kennedy, 2016; Shuilleabhain & Seery, 2018). For example, teachers participating in a collective lesson study that focused on reform mathematics showed teachers shifted their lesson planning and teaching toward more constructivist approaches (Shuilleabhain & Seery, 2018). Similarly, teachers incorporating IBL reported increased use of IBL in their classrooms after having access to an online support community with other IBL instructors (Hayward & Laursen, 2018). These studies indicate teachers move towards SCL practices with support from colleagues. However, in one study, prospective and practicing math teachers involved in planning and implementing a lesson using a rich math task tended to respond to students using teacher-directed explanations (Ayalon et al., 2021). That is, teachers responded to students by telling or explaining, instead of fostering students' mathematical discourse (Ayalon et al., 2021). This finding not only conflicts with other studies' findings, but also conflicts with SCL and is important to consider when studying teachers' conceptions and use of SCL.

Summary

Recent research has suggested that SCL approaches enhance the learning experiences for high school math students by increasing student engagement and achievement (Bishop et al., 2018; Talbert et al., 2019). Other benefits experienced by students include more collaboration and communication, more positive outlooks on mathematics, and engaging in various strategies for problem-solving. Some high school math teachers are more confident and comfortable implementing SCL approaches than their more traditional counterparts. Additionally, math teachers' beliefs about teaching and learning and their abilities to teach using constructivist pedagogies may affect their use of student-centered activities in the math classroom.

This study's theoretical framework is cognitive constructivism, teacher beliefs, and self-efficacy. These theories provide a foundation for understanding why teachers incorporate different instructional approaches in their classes. Investigating the impacts of SCL on student achievement may help educators understand the importance of implementing SCL in high school math classes. Some research has demonstrated potential benefits of SCL for students that include better achievement rates than direct instruction, increased student engagement during lessons, and the development of critical thinking skills (Bishop et al., 2018; Morrison et al., 2021; Talbert et al., 2019). Additionally, teachers were also found to benefit from the use of SCL by developing stronger student-teacher relationships, having more confidence and competence, and developing community among colleagues through open discussion and collaboration regarding pedagogical decisions (Lee & Blanchard, 2019; Morrison et al., 2021; Shuilleabhain & Seery, 2018).

However, the shift from teacher-centered, or direct learning, to student-centered instruction has not occurred frequently in mathematics (Yurekli et al., 2020). Teachers' self-efficacy and beliefs of teaching and learning may impact teachers' levels of confidence and comfort in implementing SCL (Emery et al., 2021). Studies have found relationships between teachers' beliefs and their reported use of SCL (Xie & Cai, 2020; Yang et al., 2020; Yurekli et al., 2020). The gap in the literature warrants examining teachers' views of teaching and learning with their observed use of SCL instructional practices regularly. Teachers may report using SCL approaches frequently; however, understanding the observed extent of implementing such instructional practices compared to teachers' beliefs of teaching and learning may add to this literature. This research study contributes to the existing literature by comparing teachers' views of traditional and constructivist learning to SCL practices in high school math classes.

CHAPTER THREE: METHODS

Overview

The purpose of this quantitative, correlational study is to investigate if there is a relationship between high school math teachers' conceptions of teaching and learning and the extent to which they utilize SCL strategies in their classes. This chapter introduces the design of the study, including definitions of all variables, the research question, and the null hypotheses. This chapter also includes an introduction of the participants, instrumentation, procedures, and plan for data analysis.

Design

The research design for this quantitative study is a nonexperimental, predictive correlational design (Creswell & Guetterman, 2019; Gall et al., 2007). Correlational research design aims to investigate the relationship between two or more variables, the predictor variable(s) and criterion variable(s) (Gall et al., 2007). The purpose for this study is to determine if there is a predictive relationship between the two predictor variables, high school math teachers' constructivist conceptions of teaching and learning and their traditional conceptions, and one criterion variable, the extent teachers use SCL practices in the math classroom. Correlational studies are helpful in educational studies because the results may be used to make predictions about future outcomes (Creswell & Guetterman, 2019). However, a limitation to this research design is that the correlations cannot establish cause-and-effect relationships (Gall et al., 2007). There may be other variables that affect teachers' use of SCL instructional practices.

In prediction correlational research, predictor variables are used to make predictions about future scores on the criterion variable (Creswell & Guetterman, 2019). Additionally, all variables in prediction correlational research must be quantitative and continuous (Gall et al., 2007). Data for a predication correlational study is collected from a homogenous group of participants and analyzed for possible relationships (Gall et al., 2007). In this study, the predictor variables are high school math teachers' constructivist conceptions of teaching and learning and traditional conceptions. The criterion variable is a score of the extent of SCL practices used in the math classroom. For this study, two research instruments that yield scores on a continuous scale were used to measure a possible relationship between a combination of the two predictor variables and one criterion variable, justifying a correlational study. The participants of this study are from a homogeneous group of high school math teachers. These teachers' conceptions of teaching and learning will be measured and scored prior to data collection on their use of SCL practices. The predictor and criterion variables are analyzed for possible relationships within one group.

A similar study investigated the relationship between pre-service teachers' mathematics beliefs, mathematics self-efficacy, and mathematics teaching efficacy, as well as their conceptions of teaching and learning (Lau, 2021). A predictive correlational design was used, which found that traditional conceptions, such as valuing memorization of math skills and procedures, were positively predicted by formal mathematics teaching beliefs and negatively predicted by constructivist teaching beliefs (Lau, 2021).

Research Question

RQ: How accurately can the reform-based practices score, which measures the extent of teachers' SCL practices, be predicted by the linear combination of teacher conceptions of constructivist and traditional teaching and learning?

Hypothesis

The null hypothesis for this study is:

H_0: There will be no significant predictive relationship between the criterion variable, teachers' use of SCL practices, as measured by the Reformed Teaching Observation Protocol, and the linear combination of predictor variables (teacher conceptions of constructivist teaching and learning methods and teacher conceptions of traditional methods) as measured by the Teaching and Learning Conceptions Questionnaire for high school mathematics teachers.

Participants and Setting

This section of the chapter includes a description of the population, the participants, sampling technique, and sample size. A description of the setting follows these sections.

Population

The participants for this study were drawn from a convenience sample of high school math teachers located in northeastern South Carolina during the 2022-2023 school year. In South Carolina, the school districts operate as county or sub-county units. The county where the school district is located is a midsize, suburban county. The school district's population is 77% white, 13% black, 6% Hispanic, 1% Asian, and 2% two or more races. The school district in this study is one of the largest in South Carolina, consisting of 13 public high schools serving grades nine through 12. The number of math teachers at each high school in the district varies; however, there are about 120 high school math teachers. Students in the school district are required to complete four Carnegie units in mathematics, including Algebra 1, Geometry, Algebra 2, Pre-Calculus, Probability and Statistics, or Calculus. Most, but not all, math teachers in the school district participate semi-annually in district-based PD that is rooted in principles of SCL.

Participants

The number of participants for this study is 68, which is greater than the required minimum for correlational analysis when assuming a medium effect size with a statistical power

Table 1

Participants' Demographics and Math Courses Taught (n = 68)

Characteristic	*N*	Percentage
Gender		
Male	29	42.6%
Female	39	57.4%
Math Course Taught		
Algebra 1	8	11.8%
Foundations in Algebra	8	11.8%
Intermediate Algebra	8	11.8%
Geometry	12	17.6%
Algebra 2	9	13.2%
Pre-Calculus	8	11.8%
Calculus	5	7.4%
Probability & Statistics	10	14.7%

of 0.7 at the 0.05 alpha level (Gall et al., 2007). The required minimum number for a correlational study under these assumptions is 66 teachers (Gall et al., 2007). The sample will be selected from the high school math teachers who attended the district-based PD in August 2022. Teachers will be selected based on the sessions they attended at the PD, which will incorporate the practice of SCL instruction. Table 1 shows participants' demographics and the math courses they taught while the study was ongoing.

Setting

The setting for this study is in the mathematics classrooms of the teachers included in the sample from the South Carolina school district. The classrooms may comprise any mathematics courses offered in the school district, including algebra 1, geometry, algebra 2, pre-calculus, probability and statistics, and calculus.

Instrumentation

This study used two instruments. One instrument measured the predictor variables, teachers' constructivist conceptions and traditional conceptions of teaching and learning. The other measured the criterion variable, the teachers' scores on the extent of their use of SCL practices in their classes. This section discusses the descriptions, purposes, validity, and use of each instrument.

Teaching and Learning Conceptions

The Teaching and Learning Conceptions Questionnaire (TLCQ) is used to measure the predictor variables—teachers' conceptions of constructivist teaching and learning and teachers' conceptions of traditional teaching and learning (Chan & Elliott, 2004). The purpose of this instrument is to measure teachers' beliefs about teaching and learning on a constructivist perspective and traditional perspective, as well as preferred ways of teaching and learning and the roles of teachers and students (Chan & Elliott, 2004). See Appendix E for the instrument. Permission for the use of this instrument has been granted by Bob Elliott (see Appendix F). This instrument was developed in conjunction with another instrument, the Epistemological Beliefs Questionnaire (EBQ). The researchers developed the instruments to use as a tool to investigate the relationships between teachers' epistemological beliefs and their conceptions about teaching and learning (Chan & Elliott, 2004). According to Chan and Elliott (2004), before the development of the TLCQ, there was little research on how teachers' beliefs affected their instructional practices.

Recent studies used the TLCQ to examine teachers' and pre-service teachers' educational beliefs, conceptions of teaching and learning, and their effect on teaching practices and pedagogical beliefs (Berger & Lê Van, 2019; Dejene, 2020; Yalcin İncik, 2018). Dejene (2020) used the TLCQ in a correlational study investigating the relationship between pre-service teachers' conceptions of teaching and learning and their preferred teaching method. The pre-service teachers who scored higher in the traditional teaching subscale tended to prefer traditional teaching methods (Dejene, 2020). In another correlational study, Yalcin İncik (2018) used the TLCQ to investigate the relationship between teachers' educational beliefs and their conceptions of teaching and learning on gender and years of experience. Contrary to Dejene's finding, this study concluded that females and teachers with less than five years of teaching experience were more likely to score higher on the constructivist scale (Yalcin İncik, 2018). Similarly, Berger and Lê Van (2019) found that more teaching expertise was positively associated with higher direct transmission teaching (traditional). Like these other correlational studies, the TLCQ is an appropriate instrument for measuring the current study's predictor variables.

The TLCQ is a 30-item questionnaire on a five-point Likert scale, with responses ranging from 1 being strongly disagree to 5 strongly agree. The questionnaire includes items related to traditional teaching and learning beliefs and items based on constructivist teaching and learning beliefs (Chan & Elliott, 2004). The questions were developed using instruments from related studies and interviews with teacher education students. The Cronbach's alpha for the whole scale was .86. Exploratory factor analysis resulted in two subscales, traditional and constructivist, which each had a .84 Cronbach alpha (Chan & Elliott, 2004). Chan and Elliott used confirmatory factor analysis to validate the instrument.

The questionnaire includes 18 items on the traditional subscale and 12 items on the constructivist subscale (Chan & Elliott, 2004). The traditional items are consistent with teacher-centered teaching beliefs, and the constructivist items are compatible with principles of SCL. The instrument is scored based on the two subscales, producing an average score ranging from one to five on each, constructivist and traditional. Therefore, the possible outcomes of scores range from one to five. Each participant will receive a score on the constructivist subscale and on the traditional subscale. A high score on the constructivist subscale indicates that the teacher tends to believe that learning experiences should allow students to explore and generate knowledge. A high score on the traditional subscale indicates that the teacher tends to believe traditional, teacher-directed approaches to learning are more appropriate. A lower score on either subscale indicates that the teacher does not hold beliefs in that system. The TLCQ was administered online to teachers following participation in district-based teacher PD. The questionnaire took participants approximately 20 minutes to complete. The results were scored using statistical software.

Reformed Teaching Observation Protocol

The Reformed Teaching Observation Protocol (RTOP) is used to measure the criterion variable, which is the score of the extent which teachers use SCL practices (Sawada et al., 2002). The instrument aims to measure whether mathematics or science teachers are using reform-based methods in their classrooms. See Appendix G for the instrument. Permission for the use of this instrument was granted by Daniel MacIsaac, one of the co-developers of the instrument (see Appendix H). Sawada et al. (2002) defined reformed teaching as teaching that empowers students and teachers to develop critical thinking and has a culture that supports moving from traditional to constructivist teaching and learning. Instrument development and validation was a two-year process. The authors developed the items using related literature and professional standards for mathematics and science teachers (Sawada et al., 2002). Predictive validity was determined through a series of observations collected on different community college and university campuses. Two or more trained observers completed observations of the same class and compared results immediately (Sawada et al., 2002).

Other studies have used the RTOP to investigate changes in teachers' instructional practices following PD (Blanchard et al., 2016; Davis et al., 2020; Ebert-May et al., 2015). For example, Blanchard et al. (2016) used the RTOP to measure middle school teachers' use of student-centered classroom practices before participation in PD and in the years to follow. At the post-secondary level, the RTOP was used to find differences in the teaching practices of postdoctoral fellows who participated in different versions of a PD program (Ebert-May et al., 2015). More recently, Davis et al. (2020) used the RTOP to informally observe mathematics teachers and use the data to guide conversations. Therefore, the RTOP is an appropriate tool for this study to measure the extent teachers use SCL instructional practices in high school mathematics classes.

The RTOP consists of three scales—lesson design and implementation, content, and classroom culture—confirmed using factor analysis (Sawada et al., 2002). The lesson design and implementation scale include five items concerning engaging learners in constructing knowledge based on students' prior knowledge. This scale had a Cronbach's alpha value of .91 (Sawada et al., 2002). The content scale consists of two subscales, propositional knowledge and procedural knowledge, with a Cronbach's alpha value of .80 and .93, respectively. Finally, the third scale, classroom culture, contains subscales on communicative interactions and student/teacher relationships, which both had a Cronbach's alpha value of .91 (Sawada et al., 2002). Interrater reliability was obtained using best-fit linear regression comparing different observers' scores on the same instructors' classes (Sawada et al., 2002). The scores for the pairs of observers had a correlation coefficient of .98 and 95% variance between observers (Sawada et al., 2002).

The RTOP consists of 25 items about which reformed instruction occurs in the classroom, as defined by Sawada et al. (2002). Each item is scored from 0 being never occurred to 4 being very descriptive. The possible total score can range from 0 to 100. A score ranging from 0 to 30 indicates straight lecture method, 31 to 45 indicates lecture with some student participation, 46 to 60 involves student engagement with some hands-on learning, 61 to 75 involves active student involvement in learning, and 76 to 100 indicates active student learning with inquiry and student reflection (Ebert-May et al., 2015). Observers must be trained to score the items before administering the observation tool (Ebert-May et al., 2015; Sawada et al., 2002). The RTOP website contains teaching videos with completed RTOP scoresheets as a reference (Reformed Teaching Observation Protocol, 2007). The researcher viewed each of these videos, used the RTOP to score, and compared the results to the posted scoresheets. Other studies used multiple observers (Blanchard et al., 2016; Ebert-May et al., 2015); however, for the present study, the researcher was the only observer. The observations occurred over two months. Each teacher participant was observed by the researcher in their classroom once during the two months for a 30-minute segment of their 90-minute teaching block.

Procedures

Before collecting data, an Institutional Review Board (IRB) application was sent to Liberty University and approval was granted (see Appendix A). After obtaining IRB approval, the researcher sent a research proposal to the school district (Appendix B). Once permission was granted from the school district (see Appendix C) to send the online questionnaire to high school math teachers and to conduct observations in their classrooms, the researcher obtained permission from each base school principal to complete the observations in their school building.

After all permissions were granted, the researcher emailed the potential teacher participants who attended the district-based PD. The email contained information about the purpose of the study and the data collection process, including the questionnaire and classroom observation protocol, and how the information will remain confidential. Teachers' names were collected on the surveys for the purposes of pairing their score on the TLCQ with their score on the RTOP. Only the researcher had access to this information. The email also contained details on providing consent for participation. The directions to complete the TLCQ were included in the email, with a link to the questionnaire (see Appendix D). Once teachers completed the questionnaire, they also gave consent for their mathematics classrooms to be observed by the researcher. For anonymity, the researcher assigned each teacher participant an identification number. The researcher stored data collected from the TLCQ in a protected spreadsheet that only the researcher could access. Teachers had a two-week window to complete the questionnaire. The researcher sent a follow-up email as a second request to any teachers who did not complete the questionnaire within the two-week time frame. After teacher participants completed the TLCQ, the average for the constructivist items was calculated and the average for the traditional items was calculated. Each of these scores were organized by identification number in a password protected spreadsheet accessible only by the researcher.

After the teacher participants were identified from the questionnaires, the researcher coordinated with each teachers' base school principal, instructional coach, and teacher participants to schedule days and times to begin conducting classroom observations using the RTOP. During each observation, the researcher used a Google Form to report the scores on the RTOP, which were populated into a separate spreadsheet accessible only by the researcher. The researcher used that spreadsheet to calculate the total score for each participant on the RTOP. After all observations were conducted and scored, the researcher recorded the RTOP scores into the protected spreadsheet that paired the RTOP scores with the scores from the TLCQ. The spreadsheet was saved to a password-protected drive that only the researcher can access.

Once data from each instrument was scored and recorded, the researcher reviewed the data for inconsistencies, found none, and entered the data into SPSS for data analysis. The researcher ran the data through SPSS to conduct assumption testing and multiple regression analysis to determine if a relationship exists between the predictor and criterion variables. The regression analysis explored the relationship between teachers' constructivist conceptions of teaching and learning and their scores on the RTOP, the relationship between teachers' traditional conceptions of teacher and learning and their scores on the RTOP, and the combination of constructivist and traditional conceptions on their scores on the RTOP. The researcher will report the findings from the data analysis in the findings and results sections in Chapter 4.

Data Analysis

Multiple linear regression was used to analyze the data. Multiple regression analysis is used when the researcher is examining the predictive ability for two or more predictor variables with one continuous criterion variable. Data for a multiple linear regression is gathered from one homogeneous group (Gall et al., 2007). Each participant provides one data point for each variable in the regression. The multiple regression analysis compares each predictor variable to the criterion variable and the combination of both predictor variables to the criterion variable (Creswell & Guetterman, 2019). This analysis provides the magnitude of each of these relationships and the statistical significance (Creswell & Guetterman, 2019; Gall et al., 2007).

Multiple linear regression is appropriate for the research question to investigate the predictive ability of two predictor variables, teachers' conceptions of constructivist learning and traditional learning, and the criterion variable, the score on the extent which teachers use SCL instructional practices. The data collected is from one homogenous group, high school mathematics teachers. Each teacher represents two data points, one for their conceptions of constructivist learning with their score of the extent they use SCL practices and the other for their traditional learning with their score of the extent they use SCL practices. The criterion variable and both predictor variables for this study are measured on a continuous scale.

Before analysis, the data was carefully screened for missing and inaccurate entries on all variables. No inconsistencies were found. A matrix scatter plot was used to detect potential bivariate outliers between the predictor variables and each predictor variable with the criterion variable (Warner, 2013). The assumptions for multiple linear regression with two variables are that all quantitative scores are approximately normally distributed, all pairs of variables have a linear relationship, and there is an absence of multicollinearity (Warner, 2013). Therefore, each scatter plot was examined to verify each of these assumptions. Linearity is assumed if the shape of the data is best described using a straight line (Warner, 2013). A bivariate normal distribution assumption is met if the data appear as the classic cigar shape (Warner, 2013). A variance inflation factor (VIF) test is used to verify the absences of multicollinearity. A VIF score between one and five is acceptable to meet the assumption of absence of multicollinearity (Warner, 2013).

Descriptive statistics were computed for both predictor variables and the criterion variable. A standard multiple linear regression analysis was calculated using SPSS to test the null hypothesis. If $p < .05$, the null hypothesis will be rejected, indicating a statistical relationship between the criterion and predictor variables (Warner, 2013). Regression coefficients (beta) were calculated for each variable to determine the criterion's best predictor variable (traditional conceptions score or constructivist conceptions score). Beta values indicate the magnitude of the prediction and strength of the relationship (Creswell & Guetterman, 2019). The analysis produces the multiple correlation coefficient, *R*, and the coefficient of determination, R^2 (Gall et al., 2007). The value of *R* is used to determine the effect size and R^2 gives the proportion of the variability of the combined predictor variables, traditional conceptions score and constructivist conceptions score, on the criterion variable, the score of the extent of teachers' use of SCL practices (Creswell & Guetterman, 2019). Chapter four reports the results of the data analyses.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this study was to investigate the relationship between high school math teachers' conceptions of teaching and learning measured on a constructivist scale and traditional scale using the Conceptions of Teaching and Learning Questionnaire (TLCQ) and the extent which they implement SCL instructional practices in their classes as measured by the Reformed Teaching Observation Protocol (RTOP). This chapter includes the research question considered in this study, the null hypothesis, descriptive statistics for the two predictor variables and one criterion variable, and the results of the study.

Research Question

RQ: How accurately can the reform-based practices score, which measures the extent of SCL practices, be predicted by the linear combination of teacher conceptions of constructivist and traditional teaching and learning?

Null Hypothesis

H_0: There will be no significant predictive relationship between the criterion variable, teachers' use of SCL practices, as measured by the Reformed Teaching Observation Protocol, and the linear combination of predictor variables (teacher conceptions of constructivist teaching and learning methods and teacher conceptions of traditional methods) as measured by the Teaching and Learning Conceptions Questionnaire for high school mathematics teachers.

Data Screening

The researcher sorted the data and scanned for inconsistencies on each variable. No data errors or inconsistencies were identified. A matrix scatter plot was used to detect bivariate outliers between each of the predictor variables, other predictor variables, and the criterion variable. No bivariate outliers were identified. See Figure 1 for the matrix scatter plots.

Descriptive Statistics

Descriptive statistics were obtained for each variable. The sample consisted of 68 participants, which exceeds the required minimum of 66 participants (Gall et al., 2007). The conceptions of constructivist and traditional conceptions were measured using the TLCQ on a Likert scale ranging from 1 to 5. The constructivist score for each high school math teacher was calculated as the average score on the 12 items identified as constructivist (Chan & Elliott, 2004). The traditional score for each participant was calculated as the average score on the 18 items from the TLCQ identified as traditional (Chan & Elliott, 2004). A high score on the constructivist scale indicates the teacher holds strong constructivist teaching and learning beliefs.

Figure 1

Matrix Scatter Plots

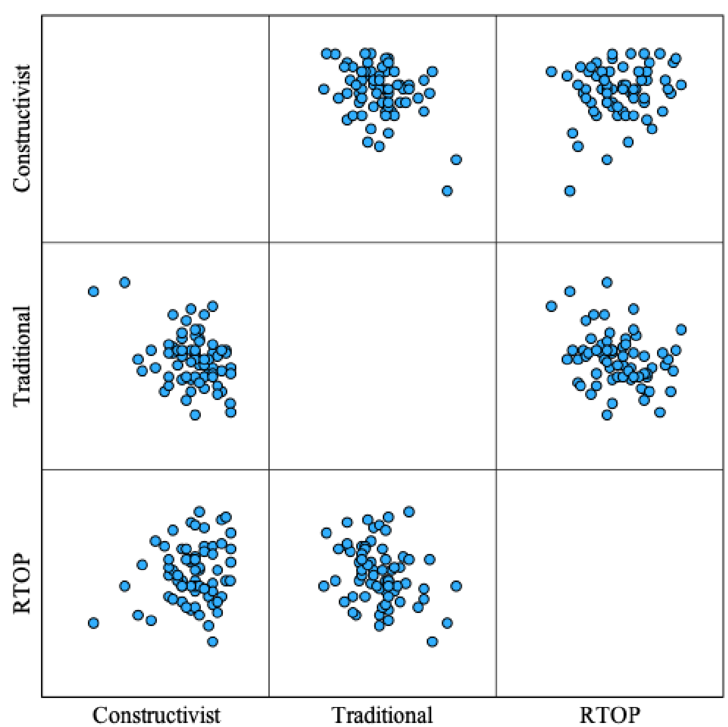

Table 2

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Constructivist	68	2.33	4.92	4.1985	.48806
Traditional	68	1.39	3.89	2.4475	.50058
RTOP	68	28.00	77.00	53.5147	10.98098
Valid N	68				

Additionally, a high score on the traditional scale indicates a teacher holds strong traditional conceptions. As shown in Table 2, the high school math teachers in the sample scored high on the constructivist conceptions of teaching and learning (M = 4.20, SD = .49). Although not as high as constructivist, the math teachers also tenedd to hold traditional conceptions (M = 2.45, SD = .50). The score from the RTOP was calculated as a total based on the level of which each item was observed during the lesson. The possible total score on the RTOP variable ranges from 0 to 100 (Sawada et al., 2002). The higher the RTOP score, the more frequently a teacher was observed using student-centered instructional practices. On average, the high school math teachers in the sample studied scored 53.5 on the RTOP scale. Descriptive statistics can be found in Table 2.

Assumption Testing

Prior to conducting the multiple regression for this quantitative, correlational study, three assumptions were tested (Warner, 2013). The assumptions for multiple linear regression with two variables are that all pairs of variables have a linear relationship, all quantitative scores are approximately normally distributed, and there is an absence of multicollinearity (Warner, 2013). A matrix scatter plot was used to test the assumptions of linearity and normality. The assumption of linearity was met. See Figure 1 for the matrix scatter plot. The scatter plots show the classic cigar shape, and thus the assumption of bivariate normal distribution was met. See Figure 1 for the matrix scatter plot. Figure 2 provides the normal P-P plot, which verifies that the data points closely follow the trend line. The normal P-P plot supports the normality assumption.

A Variance Inflation Factor (VIF) test was used to test the absence of multicollinearity. The purpose of this test is to determine if a predictor variable is highly correlated with another predictor variable (Warner, 2013). If so, they essentially provide the same information about the criterion variable. If the VIF is too high (greater than 10), then multicollinearity is present (Warner, 2013). Acceptable values are between 1 and 5. The absence of multicollinearity was met between the variables in this study, with a VIF of 1.169. See Table 3 Collinearity Statistics.

Figure 2

Normal P-P Plot of Regression Standardized Residual

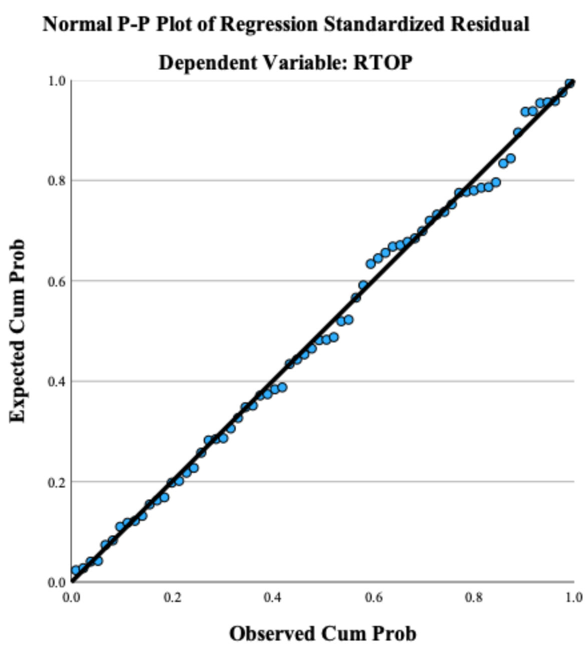

Table 3

Collinearity Statistics

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	Constructivist	.855	1.169
	Traditional	.855	1.169

a. Dependent Variable: RTOP

Results

A multiple regression was conducted to see if there was a predictive relationship between the criterion variable (extent teachers use SCL practices in the math classroom) and the linear combination of predictor variables (constructivist conceptions of teaching and learning and traditional conceptions of teaching and learning) for high school math teachers. The predictor variables were constructivist conceptions of teaching and learning and traditional conceptions of teaching and learning. The criterion variable was the extent teachers use SCL practices in the math classroom as measured by the RTOP score. The researcher rejected the null hypothesis at the 95% confidence level where $F(2, 65) = 3.427$, $p = .038$. There was a statistical relationship between the combination of predictor variables, teachers' constructivist conceptions and traditional conceptions, and the criterion variable, teachers' extent of SCL use in the math classroom. See Table 4 for regression model results.

The model's effect size was small, where $R = .309$. Furthermore, $R^2 = .095$, indicating that approximately 10% of the variance of criterion variable, use of SCL practices, can be explained by the linear combination of predictor variables (constructivist and traditional conceptions of teaching and learning). See Table 5 for Model Summary.

Table 4

Regression Model Results

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	770.671	2	385.336	3.427	.038[b]
	Residual	7308.314	65	112.436		
	Total	8078.985	67			

a. Dependent Variable: RTOP
b. Predictors: (Constant), Traditional, Constructivist

Table 5

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.309[a]	.095	.068	10.60357

a. Predictors: (Constant), Traditional, Constructivist
b. Dependent Variable: RTOP

Since the researcher rejected the null hypothesis, further analysis of the coefficients was required. Of the two predictor variables, it was found that the traditional conceptions of teaching and learning was the best predictor of the extent teachers use SCL practices in their math classes, where $p = .055$. However, neither of the predictor variables were statistically significant. Constructivist conceptions of teaching and learning did not significantly predict the extent teachers use SCL practices, where $p = .388$. See Table 6 for Coefficients.

Table 6

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	56.427	16.014		3.524	<.001
	Constructivist	2.493	2.870	.111	.869	.388
	Traditional	-5.467	2.798	-.249	-1.954	.055

a. Dependent Variable: RTOP

CHAPTER FIVE: CONCLUSIONS

Overview

Chapter Five will include a discussion of the findings of this quantitative, correlational study. The research question and the results will be discussed as they relate to the existing literature. The implications of the findings will be examined, the study's limitations explored, and recommendations for future research will follow.

Discussion

The purpose of this study was to investigate the relationship between high school math teachers' conceptions of teaching and learning measured on a constructivist scale and traditional scale using the Conceptions of Teaching and Learning Questionnaire (TLCQ) and the extent which they implement SCL instructional practices in their classes as measured by the Reformed Teaching Observation Protocol (RTOP). High school math teachers were asked to volunteer to complete a questionnaire about their conceptions of teaching and learning and allow the researcher to observe one of their math classes. The findings of this data will be presented as it relates to the current literature and the underlying theories related to the current study, cognitive constructivism, teachers' beliefs, and teacher self-efficacy.

Research Question

RQ: How accurately can the reform-based practices score, which measures the extent of SCL practices, be predicted by the linear combination of teacher conceptions of constructivist and traditional teaching and learning?

Null Hypothesis

H_0: There will be no significant predictive relationship between the criterion variable, teachers' use of SCL practices, as measured by the Reformed Teaching Observation Protocol, and the linear combination of predictor variables (teacher conceptions of constructivist teaching and learning methods and teacher conceptions of traditional methods) as measured by the Teaching and Learning Conceptions Questionnaire for high school mathematics teachers.

The researcher rejected the null hypothesis, indicating there could be a relationship between a math teachers' use of SCL practices as measured by the RTOP and the linear combination of their constructivist and traditional conceptions of teaching and learning (p = .038). However, neither the constructivist conceptions score (p = .388) nor the traditional conceptions score (p = .055) of teaching and learning had a statistically significant ability to predict math teachers' use of SCL practices. Although neither predictor variable had statistical significance, the traditional conceptions were the best predictor of the extent high school math teachers use SCL practices. This study adds to the literature by examining the predictive ability of the combination of math teachers' conceptions of teaching and learning and their use of SCL practices.

Previous research has indicated that there may be a relationship between teachers' beliefs about teaching and learning and the instructional approaches utilized in their classes (Davis et al., 2020; Dejene, 2020; Dunbar & Yadav, 2022; Ebert-May et al., 2015; Vesga-Bravo et al., 2022; Wilkie, 2019; Yang et al., 2020). The findings of this study are similar to those of Ebert-May et al.'s (2015) findings that showed college biology teachers typically reported preferring learner-centered strategies, while also scoring an average of 54 on the RTOP. However, the results in that study indicated a positive correlation on the RTOP with a student-focused dimension of teaching beliefs and a negative correlation with the teacher-focused dimension (Ebert-May et al., 2015). In the current study, a significant relationship could not be determined between constructivist conceptions and the RTOP score, nor between traditional conceptions and the

RTOP score. In another study, pre-service math teachers reported having constructivist views over traditional and reported utilizing inquiry-oriented teaching approaches, which are a type of SCL (Yang et al., 2020). Traditional beliefs had a weak, negative association with SCL instructional practices, while constructivist beliefs were positively associated with SCL instructional practices. However, neither of these studies analyzed the relationship of the linear combination of constructivist and traditional beliefs with their instructional practices.

The current study contributes to the theories indicating that teachers' actions in the classroom are impacted by their beliefs about teaching and learning, as well as other factors (Pajares, 1992; Schoenfeld, 1998). According to Pajares (1992) and Schoenfeld (1998), a person's beliefs determine their actions. This study shows that high school math teachers' classroom actions can be determined from the combination of their constructivist and traditional conceptions of teaching and learning. Historically, traditional instructional practices have been prevalent in mathematics education, with trends pushing towards reformed instruction that can be considered student-centered. The combination of constructivist and traditional conceptions found in this study may be caused by the impact that exposure to new teaching perspectives has on teachers' previous teaching and learning experiences (Chan & Elliott, 2004).

The current study adds to the previous research that high school math teachers report stronger constructivist beliefs over traditional beliefs, as the average math teacher constructivist score was 4.20 and the average traditional score was 2.45 (see Table 2). The average on the RTOP score was a 53 (see Table 2), indicating that the teachers' lessons typically involve student engagement with minds-on or hands-on activity (Ebert-May et al., 2015). The high school math teachers in the current study mostly held constructivist conceptions but had a "middling" approach to using SCL practices (Davis et al., 2020, p. 422). Middling is a term coined by Davis et al. (2020) to refer to teachers who do not associate as strictly traditionalist or constructivist but are in the middle, with tendencies to reach into one category or the other.

The teachers in the current study reported mostly constructivist teaching and learning beliefs, but the combination of these beliefs with their traditional beliefs can be used to predict their use of SCL in their classes. An essential element of cognitive constructivism sees the teacher as a guide or facilitator to help students construct knowledge (Vygotsky, 1978). The high school math teachers in this study were asked to rate statements such as, “Effective teaching encourages more discussion and hands-on activities for students” and “Learning means students have ample opportunities to explore, discuss and express their ideas” to measure their constructivist conceptions. The statements are consistent with the constructivist belief systems that students learn socially and through exploration (Stapleton & Stefaniak, 2019; Vygotsky, 1978). In contrast, statements such as, “Teaching is simply telling, presenting, or explaining the subject matter” and “Learning occurs primarily from drilling and practice” were used to measure teachers’ traditional beliefs. The combination of constructivist and traditional conceptions may be a result of high school math teachers’ beliefs that what students learn through discussions and hands-on explorations should be defined by the teacher and mastered through drill and practice.

While the high school math teachers in this study tended to hold more constructivist beliefs than traditional, their use of SCL in the classroom can be classified as middling. These practices were measured using the RTOP, which contained statements such as, “In this lesson, student exploration preceded formal presentation” and “The teacher acted as a resource person, working to support and enhance student investigations.” The teachers in this study have participated in PD opportunities that incorporated different types of SCL instructional practices, such as task-based learning and inquiry-based learning. However, the level of support the teachers received from their schools may vary from school to school. Liu and Phelps (2020) concluded that without some type of ongoing support, math teachers' knowledge regarding PD activities decays on average at a rate of 37 days following PD. In other studies, teachers who had ongoing support following PD reported consistent, continued use of SCL practices (Hayward & Laursen, 2018; Shuilleabhain & Seery, 2018). The math teachers in the current study fell into the middling category of SCL practices, which indicates they may waver between traditional and student-centered teaching practices. The level of ongoing support the teachers in the current study received may have impacted their use of SCL in their classrooms.

In contrast to the findings of the current study, Dejene (2020) found that pre-service teachers in a post-graduate teaching program typically held traditional conceptions of teaching and learning and reported preferring traditional teaching approaches. The study resulted in a positive correlation between teachers' conceptions of teaching and learning and their teaching approach (Dejene, 2020). That is, traditional beliefs were positively correlated with traditional approaches and constructivist beliefs were positively correlated with constructivist approaches. Similary, pre-service math teachers' constructivist beliefs were positively associated with their reported SCL practices, while traditional beliefs had a negative association (Yang et al., 2020). Although the high school math teachers in the current study tended to hold stronger constructivist beliefs than traditional, their use of SCL in their math classes can only be predicted by a combination of their constructivist and traditional beliefs.

The findings of the current study also support theories of teaching beliefs by Pajares (1992) and Schoenfeld (1998) that theorized teachers' beliefs about students and how they learn and beliefs about how teachers teach impact the practices teachers use in the classroom. Previous research has also shown that math teachers may hold constructivist beliefs about teaching and learning, understand SCL instructional approaches, and may implement SCL practices in their classes, but not regularly (Corkin et al., 2019; Davis et al., 2020; Yurekli et al., 2020). Corkin et al. (2019) reported that math teachers in their study described constructivist teaching beliefs and willingness to implement, but expressed constraints to utilizing such practices in their classes. Similarly, Yurekli et al. (2020) found middle level math teachers' beliefs about conceptual understanding and connection-making were greater than the frequency which they reported utilizing them. While the above studies also indicate teachers' beliefs lean towards constructivism, the teachers in these studies reported using some instructional practices in line with constructivism, which may be compared to the middling approach as with the teachers in the current study.

Implications

The theories used in this study were cognitive constructivism (Vygotsky, 1978), teachers' beliefs (Pajares, 1992; Schoenfeld, 1998), and teachers' self-efficacy (Tschannen-Moran et al., 1998). The participants in this study reported stronger constructivist beliefs than traditional but tended to implement a combination of SCL and traditional instructional practices. The high school math teachers tended to believe that students construct knowledge through social interactions and exploration, while the teacher provides guidance and helps activate prior knowledge (Vygotsky, 1978). Although the teachers participated in SCL-based PD, they did not fully implement SCL practices in their math classrooms. Several of the math teachers observed used variations of some SCL, such as task-based learning and exploration activities. For example, some teachers had students working in small groups to problem-solve a given task, while others gave students time to explore new concepts before formal instruction. However, a few of the math teachers observed used only direct instruction in their classrooms, giving students information and procedures. These teachers could have provided students with opportunities to explore concepts to build more conceptual understanding instead of procedural.

One implication is that other than teaching and learning beliefs, teachers may have further belief systems regarding students' abilities and their own abilities that may impact their classroom practices (Pajares, 1992; Schoenfeld, 1998; Tschannen-Moran et al., 1998). A high school math teacher may have strong constructivist teaching and learning beliefs; however, one cannot assume the teacher has the confidence or knowledge to implement constructivist-based practices. In the current study, participants may have had other beliefs or constraints, such as lack of confidence, that limited their use of SCL in the math classroom. In addition, Tschannen-Moran et al. (1998) noted that a teacher who is less experienced with a particular instructional approach may have lower efficacy regarding its use. Therefore, the infrequent use of SCL practices by the high school math teachers in this study may have been due to lack of experience implementing SCL. This implication may indicate that high school math teachers may need additional support and PD to help develop their confidence and experience with SCL (Copur-Gencturk & Papakonstantinou, 2016; Dunbar & Yadav, 2022; Shuilleabhain & Seery, 2018). High school math teachers may need to unlearn old, traditional practices while learning to implement the newer, less familiar SCL (Guskey, 2002; Heyd-Metzuyanim, 2019).

No other study was found that examined the predictive relationship between the linear combination of high school math teachers' constructivist and traditional conceptions of teaching and learning and their observed use of SCL in the math classroom. This study is significant to teacher educators and supporters, such as school administrators and professional development coordinators, in understanding how high school math teachers' conceptions of teaching and learning impact their use of SCL in their classrooms. The findings of this study suggest that high school math teachers who hold constructivist teaching and learning conceptions may need additional support when implementing SCL practices in their classes (Corkin et al., 2019; Guskey, 2002; Lee & Vongkulluksn, 2023; Prendergast & Treacy, 2018).

When high school math teachers implement SCL approaches, they are typically transitioning from traditional practices. Teachers must unlearn old practices while simultaneously learning to implement new ones. Professional development opportunities should help math teachers understand the principles of SCL and benefits of instructional practices involving SCL (Corkin et al., 2019; Prendergast & Treacy, 2018). Additionally, those individuals who support teachers should allow them opportunities to collaborate and share ideas and resources with other teachers using SCL approaches (Dunbar & Yadav, 2022; Lee & Vongkulluksn, 2023; Shuilleabhain & Seery, 2018). The teacher educators should provide math teachers with opportunities to practice new strategies in low pressure settings and reflect upon how the practices inform their teaching and impact student learning outcomes.

Limitations

The results of this study may have been impacted by the observational procedures. First, the observations were short, lasting no more than 30 minutes of a 90-minute teaching block. The observations took place at the beginning, middle, or end of the class, depending on school schedules and teacher availability. Therefore, the researcher may have missed some critical components of a SCL lesson depending on the time frame of which the observation occurred. Lengthening the observations to a full 90-minute teaching block or observing teachers over multiple lessons may yield different results. Additionally, because of the design of the study, the teachers knew ahead of time when their class would be observed. Causal relationship studies, such as this nonexperimental predictive study, cannot establish cause-and-effect relationships, and therefore, the relationship between the variables may be affected by other complex behaviors or patterns (Gall et al., 2007). Some teachers in the study may have strategically planned a lesson utilizing SCL practices to ensure a higher score on the observation tool.

Another limitation that affects this study's external validity was the sample. A convenience sample was used from one school district, bound to one geographic region in the Southeast United States. The sample size of 68 only slightly exceeded the minimum requirement for a correlational study, which is N = 66 (Gall et al., 2007). This study used an online survey to measure the predictor variables, which could be the cause of the low response rate (Creswell & Guetterman, 2019). The school district where the study took place employs more than 120 high school math teachers, as well as some middle school teachers who teach high school courses (algebra 1 and geometry). A larger sample size incorporating high school math teachers from different regions may impact the results of this study. The results of this study may not be generalized beyond the school district from which the sample was collected.

Another limitation is the lack of other variables that may impact a high school math teachers' use of SCL. This study only examined the relationship between the teachers' constructivist and traditional conceptions of teaching and learning with their observed use of SCL in the math classroom. Teachers' self-efficacy, experience, content knowledge, and pedagogical content knowledge were not considered. These variables may impact high school math teachers' use of SCL practices in their classroom beyond what was examined in this study.

Recommendations for Future Research

The study of teachers' conceptions of teaching and learning and how they impact their instructional practices needs further research to help identify ways to best support the teachers as they implement student-centered instructional practices. Based on the conclusions and limitations of this study, future research should consider the following:

1. a quantitative, correlational study comparing teachers' conceptions to their SCL practices using multiple observations over a longer period to obtain a more accurate representation of how often the teachers utilize SCL practices.
2. a qualitative study used to gather data on teachers' conceptions through interviews instead of self-reported data. Additionally, the observations could be conducted utilizing a different instrument that allows the researcher to collect more detailed qualitative data on classroom practices.
3. a quantitative study that measures other factors, such as experience, content knowledge, pedagogical content knowledge, and self-efficacy, that could help explain the frequency which teachers utilize SCL practices in their classrooms.
4. a quantitative study that uses a larger, more diverse sample than the current study.

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APPENDIX A: IRB Approval

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

September 20, 2022

Melissa Lute
Nathan Putney

Re: IRB Exemption - IRB-FY22-23-9 THE IMPACT OF HIGH SCHOOL MATH TEACHERS' CONCEPTIONS OF TEACHING AND LEARNING ON IMPLEMENTATION OF STUDENT-CENTERED INSTRUCTIONAL PRACTICES

Dear Melissa Lute, Nathan Putney,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under the following exemption category, which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:104(d):

Category 2.(iii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:
The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by §46.111(a)(7).

Your stamped consent form(s) and final versions of your study documents can be found under the Attachments tab within the Submission Details section of your study on Cayuse IRB. Your stamped consent form(s) should be copied and used to gain the consent of your research participants. If you plan to provide your consent information electronically, the contents of the attached consent document(s) should be made available without alteration.

Please note that this exemption only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued exemption status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this exemption or need assistance in determining whether possible modifications to your protocol would change your exemption status, please email us at irb@liberty.edu.

Sincerely,
G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office

APPENDIX B: Permission Email for School District Approval

Dear xxxxxx,

As a graduate student at Liberty University in the School of Education, I am conducting research as part of the requirements for a Ph.D. in Instructional Design and Technology. The title of my research project is The Impact of High School Math Teachers' Conceptions of Teaching and Learning on Implementation of Student-Centered Instructional Practices. The purpose of my research is to explore the relationship between high school math teachers' conceptions of constructivist instructional practices and their conceptions of traditional teaching practices with their use of student-centered learning practices in their math classes.

I am writing to request your permission to contact all high school math teachers in xxxxxxx Public Schools to invite them to participate in my research study. Participation in my research study requires two parts: 1) Participants will be asked to fill out a survey, and 2) Participants will be observed on the extent which they use student-centered learning practices in their classrooms. I am requesting school district approval to allow me, the researcher, to collect the data for the observations. Participants will be presented with informed consent information prior to participating. Taking part in this study is completely voluntary, and participants are welcome to discontinue participation at any time.

Thank you for considering my request. If you choose to grant permission, please provide a signed statement on approved letterhead indicating your approval and email to: Melissa Lute at [redacted]. Please find my written proposal attached on the following pages.

Sincerely,
Melissa Lute
Liberty University Doctoral Candidate

APPENDIX C: Permission Letter from School District

October 10, 2022

Dear Ms. Lute ,

Your request to conduct research title *The Impact of High School Math Teachers' Conception of Teaching and Learning on Implementation of Student-Centered Instructional Practices* is approved subject to the following conditions:

1. You must comply with the conditions set forth in the District policy, "Research Involving Students," and § 1232h, "Protection of pupil rights," of the U.S. Code;
2. You are not to release, present, or publish any personally identifiable information concerning students, their parents, or District staff members;
3. You are not to identify [redacted] or any school in our District in any publication, presentation, or release of information associated with your research without my written permission;
4. You are not to use [redacted] resources to complete this research;
5. The records and raw data associated with your study are to be destroyed when they are no longer needed for the purposes set forth in your request; and
6. You are to provide a copy of your completed research report to me at the District Office.

I hope your research goes well. If you have any questions or are in need of further assistance, please contact me at [redacted]

Sincerely,

[redacted]

APPENDIX D: Invitation Email to Participate in Study

Dear Math Teacher,

As a graduate student in the School of Education at Liberty University, I am conducting research as part of the requirements for a doctoral degree. The purpose of my research is to investigate the relationship between high school math teachers' conceptions of teaching and learning with their use of student-centered learning (SCL) practices in their math classes, and I am writing to invite eligible participants to join my study.

Participants must be a high school math teacher in [redacted] County Schools during the 2022-2023 school year, teaching any high school math course. Participants, if willing, will be asked to complete a survey (15 minutes) on your conceptions of teaching and learning and have a math class you teach observed (15 to 30 minutes). Names and other identifying information will be requested as part of this study, but the information will remain confidential.

To participate, please click here.

A consent document is provided as the first page of the survey. The consent document contains additional information about my research. After you have read the consent form, please click the button to proceed to the survey. Doing so will indicate that you have read the consent information and would like to take part in the survey.

Sincerely,

Melissa Lute
Doctoral Candidate, LU
[redacted]

APPENDIX E: Teaching and Learning Conception Questionnaire

Teaching and Learning Conceptions Questionnaire

School *

Your answer

The ideas of students are important and should be carefully considered.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The major role of a teacher is to transmit knowledge to students.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Learning occurs primarily from drilling and practice.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

During the lesson, it is important to keep students confined to the textbooks and the desks.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Teachers should have control over what students do all the time.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Effective teaching encourages more discussion and hands on activities for students.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Teaching is simply telling, presenting, or explaining the subject matter.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I have really learned something when I can remember it later.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Good teaching occurs when there is mostly teacher talk in the classroom.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Students have to be called on all the time to keep them under control.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Students should be given many opportunities to express their ideas.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Learning means remembering what the teacher has taught.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

A teacher's major task is to give students knowledge/information, assign them drill and practice, and test their recall.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Learning mainly involves absorbing as much information as possible.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Good students keep quiet and follow teacher's instruction in class.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

In good classrooms, there is a democratic and free atmosphere which stimulates students to think and interact.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The traditional/lecture method for teaching is best because it covers more information/knowledge.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Every child is unique or special and deserves an education tailored to his or her particular needs.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Good teachers always encourage students to think for themselves.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

The focus of teaching is to help students construct knowledge from their learning experience instead of knowledge communication.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

It is best if teachers exercise as much authority as possible in the classroom.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Different objectives and expectations in learning should be applied to different students.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Teaching is to provide students with accurate and complete knowledge rather than encourage them to discover it.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

A teacher’s task is to correct learning misconceptions of students right away instead of verify them for themselves.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Learning to teach simply means practicing the ideas from lecturers without questioning them.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

No learning can take place unless students are controlled.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Good teachers always make their students feel important.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Instruction should be flexible enough to accommodate individual differences among students.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

It is important that a teacher understands the feelings of the students.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

Learning means students have ample opportunities to explore, discuss and express their ideas.

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

APPENDIX F: Permission to Use TLCQ

Bob Elliot[redacted]
To Lute, Melissa Marie

Reply | Reply All | Forward

Wed 6/1/2022 3:56 PM

You replied to this message on 6/2/2022 8:25 AM.

Hi Melissa
I have no problem in your using the instrument but no longer have a copy. You could contact Dr Chan or maybe locate the thesis in the QUT library by contacting them

Bob

Bob Elliott
Professor Emeritus
Faculty of Education, QUT

TEL: [redacted]

Dr. Chan and Dr. Elliott,

Hello, my name is Melissa Lute. I am a candidate for the Ph.D. program in the School of Education at Liberty University. I am writing to find if you know how I can obtain access to the Teaching and Learning Conceptions Questionnaire (TLCQ). With permission, I would like to use the TLCQ for my dissertation, which I am preparing to propose.

I found your validation article online and your relational analysis study, but could not find access to obtaining permission for use. If you have a moment, I would greatly appreciate any assistance you could provide in this area.

Thank you very much,

Melissa Lute

Melissa M. Lute
Ph.D. Candidate
Liberty University
[redacted]

APPENDIX G: Reformed Teaching Observation Protocol

I. BACKGROUND INFORMATION

Name of teacher ____________________ Announced Observation? ____________________ (yes, no, or explain)

Location of class ____ (district, school, room)

Years of Teaching ____________________ Teaching Certification ____________________ (K-8 or 7-12)

Subject observed ____________________ Grade level ____________________

Observer ____________________ Date of observation ____________________

Start time ____________________ End time ____________________

II. CONTEXTUAL BACKGROUND AND ACTIVITIES

In the space provided below please give a brief description of the lesson observed, the classroom setting in which the lesson took place (space, seating arrangements, etc.), and any relevant details about the students (number, gender, ethnicity) and teacher that you think are important. Use diagrams if they seem appropriate.

Record here events which may help in documenting the ratings.

Time	Description of Events

III. LESSON DESIGN AND IMPLEMENTATION

		Never Occurred				Very Descriptive
1)	The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein.	0	1	2	3	4
2)	The lesson was designed to engage students as members of a learning community.	0	1	2	3	4
3)	In this lesson, student exploration preceded formal presentation.	0	1	2	3	4
4)	This lesson encouraged students to seek and value alternative modes of investigation or of problem solving.	0	1	2	3	4
5)	The focus and direction of the lesson was often determined by ideas originating with students.	0	1	2	3	4

IV. CONTENT

Propositional knowledge

6)	The lesson involved fundamental concepts of the subject.	0	1	2	3	4
7)	The lesson promoted strongly coherent conceptual understanding.	0	1	2	3	4
8)	The teacher had a solid grasp of the subject matter content inherent in the lesson.	0	1	2	3	4
9)	Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so.	0	1	2	3	4
10)	Connections with other content disciplines and/or real world phenomena were explored and valued.	0	1	2	3	4

Procedural Knowledge

11)	Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent phenomena.	0	1	2	3	4
12)	Students made predictions, estimations and/or hypotheses and devised means for testing them.	0	1	2	3	4
13)	Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures.	0	1	2	3	4
14)	Students were reflective about their learning.	0	1	2	3	4
15)	Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	0	1	2	3	4

V. CLASSROOM CULTURE

	Communicative Interactions	Never Occurred				Very Descriptive
16)	Students were involved in the communication of their ideas to others using a variety of means and media.	0	1	2	3	4
17)	The teacher's questions triggered divergent modes of thinking.	0	1	2	3	4
18)	There was a high proportion of student talk and a significant amount of it occurred between and among students.	0	1	2	3	4
19)	Student questions and comments often determined the focus and direction of classroom discourse.	0	1	2	3	4
20)	There was a climate of respect for what others had to say.	0	1	2	3	4
	Student/Teacher Relationships					
21)	Active participation of students was encouraged and valued.	0	1	2	3	4
22)	Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	0	1	2	3	4
23)	In general the teacher was patient with students.	0	1	2	3	4
24)	The teacher acted as a resource person, working to support and enhance student investigations.	0	1	2	3	4
25)	The metaphor "teacher as listener" was very characteristic of this classroom.	0	1	2	3	4

Additional comments you may wish to make about this lesson.

APPENDIX H: Permission to Use RTOP

DM Daniel MacIsaac <[redacted]
To Lute, Melissa Marie
Cc Kathleen Falconer; PhysPort Editor; Sam McKagan; Dan L. MACISAAC

You replied to this message on 5/19/2022 6:27 AM.

Five of those training videos are accessible from my YouTube channel:
<https://www.youtube.com/playlist?list=PLk0pzGljYOF3mxdcZ-9t1ogT8cKWMlxlZ>

There are many relevant publications as several others have used RTOP in their research. Do some groundwork, and then KF and I could be available at our mutual convenience to take your well-informed questions via Zoom.

Best wishes for your success, Dan M

Dan MacIsaac, AAPT Fellow & Professor of Physics, SUNY-Buffalo State College
[redacted]
Editor: The Science Teachers Bulletin (STANYS)

Hello,

My name is Melissa Lute and I am a Ph.D. candidate at Liberty University. I was hoping to use the RTOP as a part of my dissertation, for which I am currently preparing a proposal. I found all of the information, including the RTOP Developer's Website, on Physport.org. The sample videos in the training modules download as a .rm file, which I can open, but has no sound. I was wondering if you have any other useful information for training observers?

Thank you,

Melissa Lute
Liberty University, School of Education
[redacted]