EXAMINING SYNCHRONOUS TECHNOLOGY AND CORRECTIVE FEEDBACK IN HIGH SCHOOL MATHEMATICS COURSES: A COLLECTIVE CASE STUDY

by

Sharon B. Owens

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Philosophy

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APPROVED BY:

Wesley Scott, Ph.D., Committee Chair

Lucinda Spaulding, Ph.D., Committee Member

Abstract

The purpose of this collective case study was to present an in-depth understanding of teachers' (*N* = 9) implementing and using online synchronous technology that provides real-time corrective feedback for students in a high school mathematics course at a Christian school in Taiwan. This qualitative research design examined the implementation of platforms that provided correctives within international high schools in Taiwan. The research-based data analysis methodologies involved within-case and across-case analysis. The theories that guided this study were Bloom's (1968) mastery learning theory and Piaget's (1972) cognitive learning theory. One central research question and two sub-questions guided the study. The study included data gathered through interviews, observations, and focus groups to provide insight into how teachers implement and use technology that provides synchronous feedback in high school mathematics classrooms. Participants were high school mathematics teachers, certified by a state or recognized accreditation agency, and used an online platform as a resource for one mathematics course. This study adds to the literature by illustrating teachers' perspectives and experiences regarding the use of technology that provides synchronous feedback to high school students. The results of the study indicated that teachers need time for professional development and discovering resources. The participating teachers expressed various challenges for the student, including motivation; however, a new perspective was gained from the data presented with the corrective feedback.

Keywords: mastery learning, cognitive learning, synchronous corrective feedback, asynchronous corrective feedback, technology

Copyright Page

Dedication

I dedicate this dissertation to God, my Creator, to whom all glory is given.

To my mom, who has always been an example of hard work and who has taught me to work hard for the things that I aspire to achieve.

To my children, Logan and Josiah, who exhibited great patience with their mother through this entire process. I love you both so much!

Finally, to my amazing husband, Darryl, who has been a constant source of support and encouragement during the challenges of earning a doctorate. I am forever indebted to you for giving me the opportunity to complete this great task. Words are unable to express my sincere thankfulness and love that I have for you.

Acknowledgments

First and foremost, I would like to extend my sincere thanks to Dr. Wesley Scott for his unwavering support and belief in me, and for his assistance in every stage of this dissertation. Without his tremendous understanding and encouragement, it would not be possible for me to complete this study.

I sincerely appreciate Dr. Lucinda Spaulding for her dedication to qualitative research and higher education. She provided thoughtful comments and recommendations on this dissertation. It was an honor to have her as my methodologist.

I would also like to offer my gratitude to Morrison Academy for their support and willingness to participate in this study.

Finally, my appreciation is extended to all of my family and friends for all the encouragement and support through the many years it has taken me to finish this journey.

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List of Abbreviations

Asynchronous Correct Feedback (ACF)

Corrective Feedback (CF)

Institutional Review Board (IRB)

Synchronous Corrective Feedback (SCF)

CHAPTER ONE: INTRODUCTION

Overview

In a study conducted by Harvard Business Review, it was revealed that 57% of employees prefer corrective feedback, and 72% of the participants said they thought their performance would improve if their managers would provide corrective feedback (Zenger & Folkman, 2018). If these individuals crave corrective feedback for the bettering of the position, would high school students and educators welcome the same if they saw the benefits that corrective measures provide? One may posit that giving feedback to any learner is part of the most significant learning component that could affect the learner and educator (Bloom, 1968; Guskey, 2007, 2012, 2015). The strategies that teachers use to provide feedback may have a significant role in students' mathematical achievements (Dahal, 2016). However, corrective feedback is often neglected and not utilized or given within a timely manner.

Guskey (2008) stated, "Effectiveness of teaching is not defined based on what they do as teachers; rather, it is defined by what their students can do" (p. 29). Researchers have shown that students are capable of mastering concepts; however, the traditional teaching model does not allow for mastery (Guskey & Gates, 1986; Guskey, 2007, 2011, 2015; Khan, 2015). Many non-educational models provide evident examples of the mastery learning framework (e.g., sports, musical instruments, and martial arts) (Khan, 2015; Slavin, 1987). These examples lead one to believe that when you master the concept or goal, you may be able to participate on a travel sports team, play a more advanced instrument, or receive your next level for the martial arts belt (Khan, 2015). However, this is not the academic model (Khan, 2015).

A traditional educational model is a one-size-fits-all approach (Guskey, 2015). The approach is demonstrated by grouping all students together, followed by a lesson given by the teacher. All students complete the same assignments and homework tasks, take the same quiz, and then move onto the next lesson. Teachers provide quantitative feedback (such as a letter grade or averaged percentage) and move each student onto the next level of learning (Govaerts et al., 2013; Guskey, 2007, 2008, 2012). The cycle becomes lecture, homework, lecture, homework, and an assessment (Guskey, 2011; Khan, 2015). The assessment may identify learning gaps and point out 30 to 40% of work that a student does not know; however, the entire class will move on to the next unit (Govaerts et al., 2013; Guskey, 2011, 2012; Slavin, 1987). If the later material is not mastered, the students become discouraged and begin to believe that they are incapable of understanding concepts (Guskey, 2011, 2012; Khan, 2015). Bloom (1968) contributed significantly to education and mastery learning theory because he understood and saw the need for educational reform due to this very complex dilemma (Bloom, 1987; Eisner, 2000; Guskey, 2007; Slavin, 1987).

Further enhancing the dilemma is the use of asynchronous corrective feedback (ACF) and synchronous corrective feedback (SCF) (Beldarrain, 2007; Kutaka-Kennedy, 2015). ACF is often provided to the learner after time has elapsed, and the learner has potentially moved on to another concept or goal (Guskey & Jung, 2012; Khan, 2015). This is evident in most classrooms because of the amount of time that an educator has with students (Bloom, 1968; Guskey, 2007; Guskey & Jung, 2012); furthermore, this seems to be the most practical option to provide feedback to the learner (Gaona et al., 2018; Guskey, 2015). Contrary to ACF, online SCF is focused on real-time corrective feedback (Beldarrain, 2007; Kutaka-Kennedy, 2015). This is made possible with the use of synchronous technology. Palocsay and Stevens (2008) found that technology can simplify the creation and grading of assignments and provide opportunities for assessment testing, thus providing students with skill level opportunities to respond to appropriate and efficient learning. Additionally, Lavolette et al. (2015) stated that the effectiveness of synchronous feedback through technology is immediate and beneficial for students rather than delayed feedback (Gaona et al., 2018).

The purpose of this collective case study was to present an in-depth understanding of teacher's implementing and using online synchronous technology that provided real-time corrective feedback for students in a high school mathematics course at a Christian school in Taiwan. The following research study served to establish how educators utilized and implemented online SCF technological resources to enhance student learning as they moved towards mastery of the chosen concept. By examining these areas, the researcher explored the implications of SCF and ACF, with Bloom (1968) mastery learning theory and from a constructivist view (Glasersfeld, 1995; Guskey, 2007). This chapter includes the study's background information, description of the problem and purpose for the research, the significance of the research, and the research questions. Definitions and a summary are provided at the end of the chapter.

Background

Educational practices of the past several years that involve technology have grown in importance and relevance to teacher pedagogy (Gaona et al., 2018; Guskey, 2015; Mayer, 2003). Scholars have noted that the use of technology with the 21st-century learner requires consistent development due to the ever-increasing realm of technological advancement (Carrington, 2020; Lee, 2011; Sahin et al., 2002; Wang, 2014). Studies reveal that online SCF usage supports student learning in an English language arts course (Gaona et al., 2018; Lavolette et al., 2015; Sweigart et al., 2015). While the rapid progress of educational technological platforms continues to develop, teachers are apprehensive about utilizing them (Carrington, 2020).

When studying corrective feedback impact on learners, one must consider examining various modes of education. Online platforms are presently a growing evolvement within educational settings (Carrington, 2020). The impact of implementing online synchronous technology within high school mathematics classes that providing corrective feedback has not been extensively explored. Therefore, this study's significance may provide the researcher, educator, and administrators the understanding of utilizing synchronous technological programs to support learning for high school mathematics students. Furthermore, the educators of multiple grade levels may learn from this study and use synchronous technology in their classroom instruction.

Historical Context

Supporting student learning through various methods is not a new concept in education. Most educators try multiple means to support the student to achieve mastery of given concepts (Guskey & Jung, 2015). In the growing trend to develop technology that supports student learning, it is reported that 50% of coursework could be delivered through an online platform (Carrington, 2020; Christensen et al., 2011). Further, Christensen et al. (2011) posited that online platforms may support student motivation and tend to provide a student-centered attempt to produce opportunities for the autonomy of students resulting in a shift of pedagogy.

Bloom (1968) sought to improve teacher pedagogy that would support achievement towards mastery (Guskey, 2007). Thus, developing the mastery learning framework (Bloom, 1968; Guskey, 2007). Bloom's (1968) mastery learning framework encompasses several components from formative and summative assessments, time, and specific corrective feedback (Block & Burns, 1976; Guskey, 2007, 2011). The corrective feedback supports the learner, and the gathered informative data can help the educator make informed decisions that prompt continued learning or remediation for the learner (Guskey & Jung, 2015). However, most teaching pedagogies do not encompass the mastery framework and therefore prescribe to the traditional teaching model that is commonly known (Guskey & Jung, 2015).

Additionally, standards-based education has consistently inclined with educator awareness and institutional implementation (Guskey & Jung, 2015). However, the teaching philosophy of many does not align with the applications; thus, a continued disconnect with the rapid advancement of the educational gap worldwide (Carrington, 2020; Guskey & Jung, 2015). Furthermore, Guskey and Jung (2015) elucidated that a unique need for effectively communicating learning with students is in order, thus, advocating for educational reform with student learning at the center. Furthermore, the use of technology has rapidly advanced. It will continue to improve, allowing for the time to develop platforms that support corrective feedback, ultimately raising self-efficacy, motivation, and retention (Christensen et al., 2011; Schunk, 2016). Gaona et al. (2018) found that students in a mathematics course who received immediate corrective feedback were more efficient than students who received deferred feedback. The value of instant feedback can leverage learning and performances, thus supporting and assisting learning with accurate real-time feedback. With real-time feedback, learners may fully understand the context and remember critical details given in the provided quality feedback as applied within the cognitive learning theory (Gaona et al., 2018). Therefore, immediate corrective feedback is beneficial for student learning (Gaona et al., 2018; Lavolette et al., 2015).

Social Context

Gone are the days of paper-pencil, page-by-page textbook learning that limits the learning environment and negatively reflects the advantages of technology. With the rise of technology, traditional education is narrowing because of the resources that are afforded with technological advancements (Carrington, 2020; Gaona et al., 2018). Researchers support the idea that technology implementation that provides innovative and collaborative practices is an efficient way to instruct students effectively (Gaona et al., 2018; Lavolette et al., 2015; Wang, 2014). As online platforms and learning continue to advance current and future educators must be prepared to utilize the innovative resources that support student learning (Carrington, 2020; Gaona et al., 2018). Additionally, this study was conducted within a high school course; it could be adapted to support higher education or middle school courses. With higher educational institutions already utilizing online learning platforms and schools of education adopting the use of technologically as a constant, educators will likely continue to evolve in practice with technology, further developing the philosophy that will support the use of technological platforms and resources in the classroom (Carrington, 2020). Therefore, it is posited that all educators from elementary to the higher education profession may benefit from the gathered data available from this research.

Theoretical Context

Educational reform within the United States and internationally continues to intensify as the development of technology rapidly develops, thus supporting educational reform (Carrington, 2020; Gustyahina & Popova, 2018). The growing reliance on technology and computers means that students worldwide should be utilizing the capabilities within their present learning (Gustyahina & Popova, 2018). While technology is not a quick or easy answer to educational challenges, it supports teacher productivity that provides accurate information more quickly, allowing educators to support student learning (Guskey, 2015; Guskey & Jung, 2012; Gustyahina & Popova, 2018). Bloom's (1968) mastery learning theory and Piaget's (1972) cognitive learning theory are proponents of the ideas since technology supports the learner's feedback and cognitive abilities to recall information that is being learned (Guskey, 2007). Additionally, using platforms that provide formative data, the educator could support the learner's needs that correspond to the value of feedback found within Bloom's (1968) learning theory.

Problem Statement

Extant research has highlighted the importance of corrective feedback that supports student learning (Gaona et al., 2018; Guskey, 2015; Hussain & Suleman, 2016; Johnson & Priest, 2014; Kirschner et al., 2014; Noguera, 2013). Mathematical SCF studies are scarce despite the interest in SCF in multiple areas of research (Burgers et al., 2015; Semerci & Batdi, 2015). A plethora of research currently exists that examined the use of SCF with language arts courses and the English language learner; however, the identification of SCF and technology is rare with high school mathematics courses (Lavolette et al., 2015; Sweigart et al., 2015). This study addressed the problem by examining whether math teachers perceive synchronous corrective feedback (SCF) as a positive or negative influence on high school math students in a private school in Taiwan.

Gaona et al. (2018) found that students in a mathematics course who received immediate corrective feedback were more efficient than students who received deferred feedback. Few published research studies provide an in-depth understanding of how real-time corrective feedback may benefit the mathematics student and how teachers implement online platforms to offer corrective feedback (Gaona et al., 2018; Govaerts et al., 2013; Guskey, 2015). The overall lack of synchronous corrective online resources that provide SCF is partly due to teachers' inaccurate understanding of platforms and general reluctance to adopt such instructional techniques (Lavolette et al., 2015; Sweigart et al., 2015). Online learning resources that provide synchronous feedback have been significantly increasing over the past decade. Some high school subjects have seen increasing usage of the online resources (e.g., English Language Arts, English Language Learning programs); however, many high school mathematics teachers have not utilized the resources that provide SCF (Gaona et al., 2018; Guskey, 2015; Hussain & Suleman, 2016; Sobhani & Tayebipour, 2015; Sweigart et al., 2015). Furthermore, studies have not yet linked technology and SCF to support student learning towards mastery in high school mathematics courses.

Purpose Statement

The purpose of this collective case study was to present an in-depth understanding of teacher's experiences implementing and using online synchronous technology that provides real-time corrective feedback for students in a high school mathematics course at a Christian school in Taiwan. For this study, mastery of the high school math student was defined as whether a student uses synchronous technology to achieve mastery of the assigned content. This collective case study explored synchronous technology that provides SCF for high school mathematics students at a Christian school in Taiwan. This research gave high school mathematics teachers a voice regarding their experiences implementing and utilizing the online SCF and ACF platforms to support student learning. The theories used to guide this study were Bloom's (1968) mastery learning theory and cognitive learning theory (Guskey, 2007; Piaget, 1972).

Significance of the Study

I was compelled to complete this research because of the rapid development of technological resources available for teachers and learners (Kirschner, 2014). The research study addressed the gap in the literature that adds to the body of knowledge concerning the experiences of how teachers implement and use online synchronous technology that provides real-time corrective feedback impact on student learning. Bloom's (1968) mastery learning framework highlighted the necessity for corrective feedback after formative assessments are given (Guskey, 2007, 2015). Additionally, Bloom's (1968) mastery learning theory explained that instruction combined with corrective measures is the key to effective learning (Guskey, 2007, 2015). If teachers do not allow for the real-time corrective measures, a learning opportunity may be lost, resulting in an impact on student achievement (Guskey, 2015; Kirschner et al., 2014; Lavolette et al., 2015).

This study may benefit the growing trend of online learning and technology by understanding how teachers perceive technology to impact student learning. Additionally, the study could help future courses or programs prepare teachers for the rapid advancement of technological implementation. The study may assist future teachers and educational leaders in adjusting instruction that continues to advance the awareness of instructional implementation corrective feedback through online platforms.

The site that was studied was an international Christian school. The school's vision for their learners suggests that students and teachers are innovative in their approach to learning and teaching; therefore, this study promoted the innovative approach using technology in high school mathematics courses. The school may benefit from the teacher's understanding of the use of technology through online platforms, thus supporting the innovation mission that it seeks to promote. Furthermore, student retention and learning may increase with the use of the SCF platforms.

Research Questions

The research study of teachers' perception of implementing online SCF platforms was guided by one central research question and two sub-questions. The research questions cover the characteristics of the corrective framework found in many synchronous resources. The research questions were grounded in Bloom's (1968) mastery learning theory and the cognitive learning theory (Guskey, 2007; Piaget, 1972). Corrective feedback is at the core of Bloom's framework, thus embedding the nature of this research study (Guskey, 2007).

Central Research Question

How do high school mathematics teachers implement and use online learning platforms that provide real-time corrective feedback? The central research question guided this study provided described experiences of using synchronous technology into their mathematics classrooms. This central question is open-ended with a design to elucidate the experiences of the high school mathematics teachers as they use a technological platform that provides synchronous corrective feedback (Patton, 2015). For educators to follow the mastery learning framework they must provide feedback to their learners thus supporting Piaget's (1972) cognitive learning theory (Sweigart et al., 2015). Providing feedback in an asynchronous context prolongs the application of feedback, resulting in lack of motivation or learning (Collins et al., 1987; Lavolette et al., 2015; Sweigart et al., 2015). The learner having the opportunity to have real-time corrective feedback with a synchronous platform is a vital resource and educators should utilize the innovative practices.

Sub-Question One

How do high school mathematical educators describe their interactions with the synchronous platforms that provide real-time corrective feedback?

Sub-Question Two

How do mathematics teachers perceive the support level of synchronous, online corrective feedback in high school mathematic courses?

Definitions

The following definitions of terms provide clarity and guidance to aid the readers in fully comprehending the intended research.

1. *Asynchronous Corrective Feedback* - Is feedback that takes place after students have completed the formative assessment; the teacher provides feedback on finished material for a period of time after the students have submitted their assessments (Quinton, & Smallbone, 2010).
2. *Corrective Feedback* - Corrective feedback may be defined as information given to an individual or group to correct a behavior, thought, or action (Block, 1972; Bloom, 1968; Guskey, 2007; Hattie & Timperley, 2007).
3. *Real-time Feedback* - Real-time feedback aims to provide learners with frequent feedback about their performance on a given learning target (Gaona et al., 2018).
4. *Synchronous Corrective Feedback* - Synchronous corrective feedback (SCF) occurs in an online computer-mediated environment in which the teacher provides corrective feedback (CF) while students are in the process of completing their mathematical assessments (Kirkwood & Price, 2014).
5. *Synchronous Technology* - Synchronous technology is any online platform that provides a learning environment that may provide opportunities for learners to be active with their teachers or peers while learning a specific concept (Kutaka-Kennedy, 2015).

Summary

Currently, a plethora of research exists that examines the use of SCF with language arts courses and the English language learner; however, the identification of SCF and technology do not exist with a high school mathematics course (Gaona et al., 2018; Guskey, 2015; Hussain &

Suleman, 2016; Sobhani & Tayebipour, 2015; Sweigart et al., 2015). A gap exists in the peer-reviewed literature on high school mathematics teacher's usage of synchronous technological resources that provide real-time CF. Therefore, the purpose of this collective case study was to present an in-depth understanding of teacher's experiences implementing and using online synchronous technology that provided real-time corrective feedback for students in a high school mathematics course at a Christian school in Taiwan. This chapter provided the background of the problem, the problem statement, research questions, and the significance of this study. Additionally, a brief explanation of the personal relations with the research and relative worldview is provided with the historical, social, and theoretical contexts. Finally, the chapter provided definitions for a comprehensive understanding.

CHAPTER TWO: LITERATURE REVIEW

Overview

Chapter Two includes a theoretical framework for the study and a review of existing literature pertaining to the perceptions of teachers who implement and use online synchronous technology that provides real-time corrective feedback for students in a high school mathematics course**.** Technological platforms that enhance student learning, teacher support, and educational institutes are rapidly developing (Gustyahina & Popova, 2018; Mathews et al., 2017). These platforms are designed to support student learning outcomes (Akbar, 2017; Beldarrain, 2007; Collins et al., 1987; Gustyahina & Popova, 2018; Mathews et al., 2017). With the rapid development of such platforms, teacher utilization, professional development, and perception are at the forefront; thus, research must be conducted to understand the perception of teachers who utilize the online learning platforms that provide real-time corrective measures (Gaona et al., 2018; Kutaka-Kennedy, 2015).

According to multiple researchers, it is suggested that when corrective feedback is provided to the learner in a synchronous real-time manner, overall student learning and retention are enhanced (Gaona et al., 2018; Guskey & Gates, 1986; Guskey, 2015; Hadiyanto, 2019). However, little research is available detailing teachers' perceptions of implementing online platforms in a high school mathematical classroom setting that supports students understanding of providing SCF. With the increase of online learning platforms, research must be conducted to understand the needs of high school mathematics courses. This research study provides an opportunity to understand and explain how implementing online synchronous corrective feedback through platforms such as Desmos progresses students toward mastery within high school mathematics courses.

This chapter includes a systematic review of the literature examining SCF and ACF when given through the utilization of online platforms with high school mathematics teachers. Within the area of study, the focus is on real-time corrective feedback while utilizing synchronous technology. This chapter presents a review of the current literature related to the topic of study. Bloom's (1968) mastery learning model and Piaget's (1972) cognitive learning theory framed and guided this study (Garrison et al., 1999; Guskey, 2007, 2015; Brookhart et al., 2016). The theories were discussed to provide the theoretical framework, followed by a synthesis of recent literature regarding corrective feedback while utilizing synchronous technology. A gap in the literature was identified, presenting a viable need for the current study.

Theoretical Framework

The theoretical framework that guided this research study comes from two theories: Bloom's (1968) mastery learning theory and Piaget's (1972) cognitive learning theory (Guskey, 2007). Understanding this foundational framework provides the scope of which this study was examined.

Mastery Learning Theory

Bloom (1968) proposed mastery learning as an instructional strategy (Guskey, 2007). Bloom's theory was based on the premise that students can learn the content but equates to educators controlling the conditions for success by stating all students can learn excellently (Guskey & Gates, 1986; Guskey, 2007; Hopfenbeck, 2020; Mathews et al., 2017). Bloom's mastery learning theory states that students can learn with the correct instruction and time to learn the material (Akbar, 2017; Block & Burns, 1976; Guskey, 2007, 2015; Guskey & Gates, 1986). Bloom (1968) proposed and developed the mastery learning theory as an instructional strategy and educational philosophy that supports feedback as a vital component to the learner

(Guskey, 2007; Hussain & Suleman, 2016). Bloom's (1968) mastery learning framework is based on the premise that with correct instruction and time to learn the material, all students can achieve the desired objectives at satisfactory levels (Guskey, 2007; Hussain & Suleman, 2016).

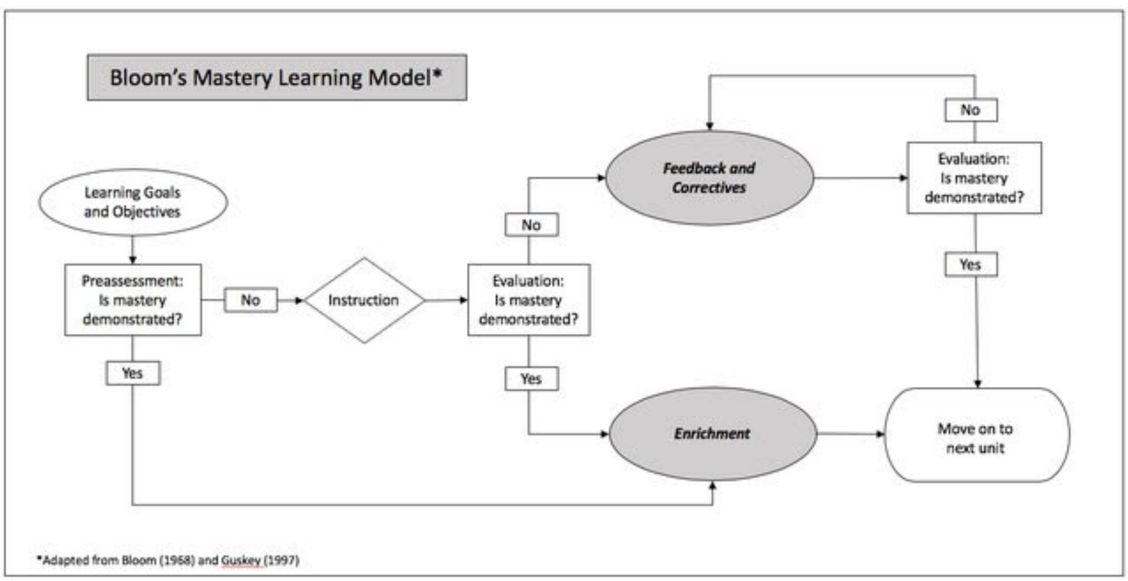
The philosophy behind Bloom's (1968) theory may not fit the traditional teaching pedagogy but has been found to support student's learning for mastery (Guskey, 2007, 2015; Guskey & Gates, 1986; Mathews et al., 2017). Within Bloom's (1968) mastery learning framework, feedback is essential to student learning, thus providing the learner support to learn the selected material (Guskey & Gates, 1986; Guskey, 2007, 2015).

Additionally, outlined in Bloom's (1968) mastery learning theory is an instructional process, reinforcement through enrichment, feedback, and corrective measures are present (Guskey, 2015). Guskey (2015) stated, "Paired with formative assessments are specific 'corrective' activities for students to use in correcting their learning difficulties" (p. 754). Furthermore, feedback is vital to the mastery learning method (Akbar, 2017; Block & Burns, 1972; Miller, 2013; Orrell, 2006). Guskey (2015) suggested that by offering direction and guidance, the students will remedy their learning problems, and successful mastery of the learning outcomes will be presented.

Bloom's (1968) research into the theory postulated that students need to show mastery of given concepts; however, the traditional approach to teaching is that teachers continue teaching through learning outcomes rather than provide feedback or provide correctives on the identified unlearned information (Guskey, 2007, 2015; Hopfenbeck, 2020; Mathews et al., 2017). Following Bloom's (1968) mastery learning framework, achievement gaps are evident through the gathered formative assessment data (Guskey, 2007, 2015; Gustyahina & Popova, 2018; Lipnevich et al., 2020).

Bloom (1968) suggested that one should master the criterion at the determined mastery level, regardless of how many tries it takes to achieve the criterion score (Guskey, 2007; Mathews et al., 2017; Slavin, 1987). Bloom (1968) posited that feedback and corrective activities are crucial elements of the theory that align with effective teaching measures which are central for student learning and retention of assessed content (Akbar, 2017; Block, 1972; Block & Burns, 1976; Guskey, 2007, 2015; Guskey & Gates, 1986; Lipnevich et al., 2020; Mathews et al., 2017; Slavin, 1987). Furthermore, Bloom (1968) found that with the corrective measures, students were able to retain the information, and the achievement gap lessened as the students progressed through the given course; therefore, motivation and retention of the learning outcomes were apparent, and support was provided for further instructional areas as seen in Figure 1 (Collins et al., 1987; Guskey, 2007, 2015).

Figure 1.



Note. Bloom's Mastering Learning Model. Reproduced with permission from "Mastery Learning in Early Childhood Mathematics Through Adaptive Technologies," Betts, 2019. Retrieved from https://www.researchgate.net/publication/331887845

Bloom's (1968) mastery learning theory is based on the premise that with correct instruction, correctives, and time to learn the material, all students can achieve the desired objectives at satisfactory levels (Guskey, 2007, 2008, 2015; Hussain & Sullivan, 2016). Students who meet the mastery level will obtain prerequisite knowledge before advancing to the next unit or material (Guskey, 2007; Hopfenbeck, 2020; Lipnevich et al., 2020). Amiruddin et al. (2015) stated, "Students are likely to fail if they do not acquire this prerequisite knowledge because they do not have the appropriate cognitive skills and sets of information" (p. 184).

The concepts that inform the phenomenon for this collective case study are found within the theoretical framework (Yin, 2018). Bloom's (1968) mastery learning theory significantly supported the literature review, data collection, and data analysis (Guskey, 2007, 2015).

Cognitive Learning Theory

Piaget (1972) is the prominent theorist that constructed the cognitive learning theory (Craik & Lockhart, 1972; Dasen, 1994; Glaserfeld, 1995; Pandey, 2018; Schunk, 2016). The cognitive learning theory is based on creating long-term memory of information received in stages (Pandey, 2018; Sternberg et al., 2016). The theorist compared the human mind to a computer or information processor (Pandey, 2018; Sternberg et al., 2016). The theorist described the process of taking short-term memory, which is the immediate awareness of concepts and encoding to the long-term memory (Pandey, 2018; Sternberg et al., 2016). The long-term memory has life's events stored even though, at present, you may not recall the information (Mathews et al., 2017; Pandey, 2018; Schunk, 2016; Sternberg et al., 2016). The process of bringing long-term memory to short-term memory is retrieval—all of the methods of storing information work together to support the learner (Pandey, 2018; Schunk, 2016).

The psychology behind the cognitive learning theory identifies and describes mental processes that affect behavior, learning, thinking, and conditional attributes that affect the mental processes (McSparron et al., 2019; Pandey, 2018; Schunk, 2016). Learning is affected by external and internal factors; therefore, understanding that using thinking to learn is a part of the cognitive process (Pandey, 2018; McSparron et al., 2019). Memory is critical for learning, and how information is learned determines how it is stored in and retrieved from memory (Fyfe & Rittle-Johnson, 2017; Mathews et al., 2017; McSparron et al., 2019; Pandey, 2018; Schunk, 2016; Sternberg et al., 2016). Researchers posited that remembering should be regarded as an activity of the mind rather than a collection of structural memory traces waiting to be revived because of the levels of processing (McSparron et al., 2019; Pandey, 2018; Sternberg et al., 2016).

Piaget (1972) is the prominent theorist; however, researchers Lewin, Gagnes, Bloom, and Anderson are significant to the further development of the theory (Pandey, 2018; Spyropoulou et al., 2013). The researchers posited that the cognitivist approach suggests that understanding, retaining, and recalling information through the use of cognitive strategies support student learning (Chang & Yang, 2010; Mathews et al., 2017; McSparron et al., 2019; Pandey, 2018; Radmehr & Drake, 2018; Spyropoulou et al., 2013). Bloom's (1968) development of cognitive taxonomy, commonly known as Bloom's Taxonomy, enhances the cognitive development of student learning (Guskey, 2007; Mathews et al., 2017; Pandey, 2018; Radmehr & Drake, 2018; Spyropoulou et al., 2013). The taxonomy supports how learning skills focus on the thinking domain (Chang & Yang, 2010; Mathews et al., 2017; Radmehr & Drake, 2018).

How Both Theories Informed the Study

Both the mastery learning theory and cognitive learning theory informed this study because the components of each theory should be present within the learning environments. Spyropoulou et al. (2013) posited that creating learning environments that encourage students to connect with previously learned material is an instructional design that promotes cognitivism. Therefore, the use of synchronous technology may support the learner as they develop the knowledge of the content. The learner is viewed as the information processor; thus, cognitive-based technology attempts to keep the learner's attention while supporting their mental activities to a new level through instructional explanations and demonstrations that are present within Bloom's (1968) mastery learning theory (Chang & Yang, 2010; Craik & Lockhart, 1972; Guskey, 2015; Hopfenbeck, 2020; Lipnevich et al., 2020; Mathews et al., 2017; Radmehr & Drake, 2018; Spyropoulou et al., 2013; Sternberg et al., 2016). Therefore, new information may be easily stored and understood (Chang & Yang, 2010; Lipnevich et al., 2020; Mathews et al., 2017; Pandey, 2018; Radmehr & Drake, 2018; Spyropoulou et al., 2013; Sternberg et al., 2016).

Gagné, an American educational psychologist, proposed nine conditions for learning while considering cognitivism, that educators should consider when designing instruction all are relevant to Bloom's (1968) mastery learning theory (Clark, 2018). Notice that within the conditions the elements of providing feedback, assessing performance, and enhancing retention and applying it to a job are considered (Clark, 2018). Figure 2 provides Gagné's conditions and a brief explanation of the nine conditions (Clark, 2018).

Figure 2.

Gagné's 9 Conditions of Learning[4]	
Condition	**Examples**
Gain attention	Use current news or case studies to grab learners' attention and interest in the lesson. Use clickers and surveys to ask leading questions before the lecture.
Inform learners of objectives	Include learning objectives in lecture slides, syllabus, and class activities. Use strong action verbs that can be measured accordingly.
Stimulate recall of prior learning	Ask questions about previous personal experiences. Ask learners about their understanding of previous concepts.
Present the content	Use a variety of methods (eg, lecture, various instructional strategies, projects, and multimedia). Use a variety of media to address different learning preferences.
Provide learning guidance	Provide instructional support as needed. Include rubrics and assessment guides. Provide expectations, detailed instructions, and timelines.
Elicit performance (practice)	Have learners collaborate with peers to apply knowledge. Ask leaners to recite, revisit, or reiterate information gained from the lesson or activity.
Provide feedback	Provide detailed feedback on assignments to show learners what was done correctly, what must be improved, and why changes are necessary. Vary feedback approach (eg, peer-review, self-assessment).
Assess performance	Use a variety of assessments that relate to instructional objectives.
Enhance retention and transfer to the job	Provide opportunities for learners to relate coursework to personal experiences or other real-world situations. Have learners create graphic organizers (eg, concept maps) to demonstrate comprehension of new content.

Note. This graph was produced by Clark in 2018, summarizing Gagné's Conditions for Learning: Cognitivism that influences the performance of learners. From "Learning Theories: Cognitivism," by K. Clark, 2018, *Radiologic Technology, 90*(2), p. 178. Copyright 2018 by Radiologic Technology.

Conclusion

The research involved within this study focused on an in-depth understanding of teachers implementing and using online synchronous technology that provided real-time corrective feedback for students in a high school mathematics course. This research sought to advance the existing literature and theories on corrective feedback that is provided in a synchronous manner, thus promoting Bloom's (1968) mastery learning theory with the idea of greater cognitive achievement among students.

Related Literature

Researchers have provided substantial information to support student learning (Hopfenbeck, 2020; Lipnevich et al., 2020; Sato & Loewen 2018). Most schools provide numerical evidence that equates the amount of learning for administrative and informative purposes (Guskey & Gates, 1986; Hopfenbeck, 2020; Lipnevich et al., 2020; Sato & Loewen 2018). However, learning that is determined by a quantitative value does not provide students with the necessary information to fully develop an understanding of the concepts that are being learned (Guskey & Gates, 1986; Hopfenbeck, 2020; Hussain & Suleman, 2016; Lipnevich et al., 2020; Sato & Loewen 2018). Instead, researchers posit that learning combined with correctives supports student learning and retention of concepts (Guskey & Jung, 2015; Hussain & Suleman, 2016; Lipnevich et al., 2020; Sato & Loewen 2018).

Bloom (1968) elucidated within his research the need for students to have the opportunity to learn within a framework that provided correctives is imperative, thus, ensuring students understand the concepts before moving to the next phase of learning (Chang & Chen, 2020; Guskey, 2007; Lipnevich et al., 2020; Sato & Loewen 2018). Therefore, Bloom (1968) proposed mastery learning as an instructional strategy and educational philosophy (Guskey, 2007; Hussain & Suleman, 2016). The following review of relevant literature includes current research and literature that pertains to SCF as it relates to Bloom's (1968) mastery learning theory and Piaget's (1972) cognitive approach (Guskey, 2007).

Pedagogy and Assessments

Guskey (2008) stated, "Effectiveness of teaching is not defined on the basis of what they do as teachers; rather, it is defined by what their students are able to do" (p. 29). How can we define effective teaching? Should students be capable of merely recalling information and placing the correct response on an assessment? Research has shown that students can achieve mastery of concepts; however, the traditional teaching model does not allow for mastery (Chang & Chen, 2020; Guskey, 2008; Hussain & Suleman, 2016; Khan, 2015; Lipnevich et al., 2020; Sato & Loewen 2018; Shawer, 2017). Many non-educational models are evident in the mastery learning framework (e.g., sports, musical instruments, and martial arts) (Guskey, 2015; Khan, 2015; Toothaker & Taliaferro, 2017). These examples lead us to believe that when you master the concept or goal, you may be able to participate on a travel sports team, play a more advanced instrument, or receive your next level for the martial arts belt (Khan, 2015). However, this is not the academic, pedagogical model that promotes learning for mastery (Chang & Chen, 2020; Guskey, 2015; Khan, 2015; Toothaker & Taliaferro, 2017).

The traditional academic model that is considered to be effective teaching pedagogy is to group every student within a course, host a lecture, have the students complete a task, complete the outside of class work, and then take a quiz or some type of assessment content (Hussain & Suleman, 2016; Khan, 2015; Lipnevich et al., 2020; Toothaker & Taliaferro, 2017). The students will then move on to the next lesson or framed content (Guskey, 2015; Hussain & Suleman, 2016; Khan, 2015; Lipnevich et al., 2020). The cycle becomes lecture, homework, lecture, homework, and then an assessment (Khan, 2015; Shawer, 2017; Toothaker & Taliaferro, 2017). The assessment will identify learning gaps and point out 30 to 40 percent of the work that a student does not know; however, the entire class will move on to the next unit (Guskey, 2015; Khan, 2015; Toothaker & Taliaferro, 2017). If the later material is not mastered, the students become discouraged and begin to believe that they are incapable of understanding concepts (Guskey, 2015; Hussain & Suleman, 2016; Lipnevich et al., 2020; Mathews et al., 2017; Noguera, 2013). The learner is assessed and then moves through the content without remediation for the identified learning gaps (Guskey, 2015; Lipnevich et al., 2020; Toothaker & Taliaferro, 2017).

Bloom, an American educational psychologist and expert educator, contributed significantly to education and the theory of mastery learning because he understood and saw the need for educational reform due to this very complex dilemma with teaching pedagogies (Block, 1972; Bloom, 1968; Guskey, 2007; Eisner, 2000; Mathews et al., 2017; Shawer, 2017). Furthermore, researchers Toothaker and Taliaferro (2017) posited that the emergence of Millennial students represents the need for an aggressive move away from the traditional pedagogy but to a practice that will involve learners and provide engagement opportunities such as experiential learning, collaborative approaches, and instantaneous feedback.

If cognitive skills are lacking, the students fall behind because they cannot integrate the new information with the new content areas as they are taught (Clark, 2018; Hussain & Suleman, 2016; Noguera, 2013; Pandey, 2018; Shawer, 2017; Toothaker & Taliaferro, 2017). Therefore, gaps in academic performance become evident (Khan, 2015; Shawer, 2017). Gaps that are closely related to early education are known as the preparation gap (Khan, 2015; Noguera, 2013; Shawer, 2017).

Learning gaps may become apparent in areas of education, specifically within a mathematical context that is related to this research. Noguera (2013) suggests that when these gaps exist in student learning, the cognitive realm increases, and an achievement gap is present, thus leaving the student with noticeable gaps with prerequisite knowledge as they continue to the next subject or in the case of this research the mathematical unit. Under the mastery learning theory, students exhibit a learning gap because they have not developed the cognitive skills required during the learning process (Bloom, 1968; Guskey, 2007; Mathews et al., 2017;

Noguera, 2013; Pandey, 2018; Shawer, 2017; Spyropoulou et al., 2013). These skills would be required if the mastery learning method was used as the teaching method (Guskey, 2015; Shawer, 2017).

Cognitivist approach instruction with the mindset of making learning meaningful and organized while relating new information to prior knowledge (Clark, 2018). According to Clark (2018):

> In cognitivism, learning is less about what learners do and more about what they know and how they come to acquire that knowledge. Instructors must analyze and find appropriate instructional activities to help learners effectively and efficiently process information. Cognitive psychologists believe instructors should remember that new information most easily is acquired when learners can associate it with information they have already learned. Finally, learning results when information is stored in memory in an organized, meaningful manner. As learners grow, they become capable of thinking in more sophisticated ways and organizing their thought processes logically (p. 177).

Pedagogical principles are imperative to the mastery learning theory related to instruction (Alt, 2015; Chen & Bonner, 2016; Clark, 2018; Iskander, 2014; Mathews et al., 2017; Shawer, 2017). Thus, the assessment process is crucial for student learning and retention within mathematical courses (Burgers et al., 2015; Clark, 2018; Semerci & Batdi, 2015; Mathews et al., 2017; Shawer, 2017). Furthermore, the use of corrective feedback to support student learning, as suggested by theorists and researchers, should enhance student learning, promoting retention and positive self-efficacy (Clark, 2018; Mathews et al., 2017; Porte et al., 2007; Quinton & Smallbone, 2010; Shawer, 2017).

Summative and Formative Assessments

Formative and summative assessments are both opportunities for the learner to show what they have learned (Bacquet, 2020; Connors, 2021; Guskey, 2015). Formative assessments are administered as the learner moves through the learning process; summative assessments are final assessments (Connors, 2021). Both assessment types provide multiple stakeholders with necessary data to support student learning (Brookhart et al., 2016; Connors, 2021). Researchers posited that regularly administering formative assessments is essential to help students progress and succeed on summative assessments (Bacquet, 2020; Brookhart et al., 2016; Connors, 2021; Dixson & Worrell, 2016; Guskey, 2015). Both of the assessment structures support each other (Bacquet, 2020; Connors, 2021). Jovanović (2019) stated that "Formative assessment is an important aspect of learning which includes providing continuous assessment, and providing detailed information about achievement as well as support for future learning and progress" (p. 2).

Guskey (2015) posited that assessments alone could not improve student learning; it is what we do with the results that count. Assessments are necessary to measure student understanding and comprehension of learning targets; thus, a comprehensive measure of both formative and summative is essential for both students and educators (Guskey, 2015; Bacquet, 2020; Brookhart et al., 2016; Connors, 2021). The Assessment Reform Group states:

> Assessment for learning should be recognized as central to classroom practice. Much of what teachers and learners do in classrooms can be described as assessment. That is, tasks and questions prompt learners to demonstrate their knowledge, understanding and skills. What learners say and do is then observed and interpreted, and judgements are made about how learning can be improved. These assessment processes are an essential part of

> everyday classroom practice and involve both teachers and learners in reflection, dialogue and decision making (Broadfood et al., 2002, p. 2).

Schuldt (2019) stated that "Feedback to students is a central piece of the formative assessment process that allows teachers to monitor student progress and provide information to close the gap between current performance and the learning goals" (p. 64). Joughin and Macdonald (2004) posited that having a model of assessment will help guide the assessment process by identifying critical points for intervention, improving evaluation within the system, and gathering the success or failures of a particular part. Additionally, it is noted that when the students do the heavy lifting through formative practice, assessment, and corrective feedback, the summative assessment should not feel burdensome (Bacquet, 2019; Connors, 2021; Dixson & Worrell, 2016; Joughin & Macdonald, 2004; Schimmer et al., 2018). According to Schimmer et al. (2018), summative assessments should be an opportunity to celebrate learning.

Therefore, formative assessments that provide corrective feedback ultimately support student learning and guide teaching practices (Bacquet, 2019; Brookhart et al., 2016; Chen & Bonner, 2016; Connors, 2021; Dixson & Worrell, 2016). Bloom's (1968) mastery learning theory framework suggests that both formative assessments and corrective feedback are essential to student learning; therefore, providing the relevant knowledge as found in Bloom's taxonomy to support learning and retention (Amiruddin et al., 2015; Bloom, 1968; Connors, 2021; Guskey, 2008, 2015; Hussain & Sullivan, 2016; Schimmer et al., 2018). Augustine et al. (2015) found a significant increase in student learning based on the assessment design, ultimately supporting the implementation of the methods of assessments. Ensuring that students can learn formatively and then produce evidence of completion of learning through a summative evaluation is key to student learning (Amiruddin et al., 2015). Additionally, online platforms that provide formative data for both the educator and student learner are considered valuable due to the external factors that influence both participants' processes within the learning cycle (Brookhart et al., 2016).

Researchers contend that providing correctives within the formative evaluation process will support overall student learning (Amiruddin et al., 2015; Bacquet, 2020; Brookhart et al., 2016; Connors, 2021; Guskey, 2015; Schimmer et al., 2018). This provides the cognitive awareness that is needed for learning growth (Bacquet, 2020; Mathews et al., 2017; Pandey, 2018; Radmehr & Drake, 2018; Toothaker & Taliaferro, 2017). As learning environments continue to evolve through assessment data, one must expect technology that provides formative or summative assessments would be at the forefront of teaching and learning, thus, the notion that technology may support the learner and further the learning process (Carrington, 2020).

Corrective Feedback

"Feedback has been considered a crucial element to the process of learning" (Soltanpour & Valizadeh, 2018, p. 125). Corrective feedback may be defined as information given to an individual or group to correct a behavior, thought, or action (Block, 1972; Bloom, 1968; Hattie & Timperley, 2007; Sato & Loewen, 2018). Corrective feedback is also commonly called interactional feedback (Akbar, 2017). The opportunity for a learner to receive corrective feedback supports learning and retention, ultimately supporting a critical element of Bloom's (1968) mastery theory providing the learner with a substantial learning growth (Collins et al., 1987; Fyfe & Rittle-Johnson, 2017; Guskey, 2007; Sweigart et al., 2015). Theoretically, corrective feedback is primarily about information processing affecting the learner positively (Fyfe, & Rittle-Johnson, 2017; Sternberg et al., 2016).

Learning from feedback is often viewed as an interaction between information in long-term memory and the new information provided in the feedback message (Fyfe, & Rittle-

Johnson, 2017; Sternberg et al., 2016). Internal feedback and cognitive routines are created, while effective learners are engaged in academic tasks (Hattie & Timperley, 2007; Sato & Loewen, 2018). Schunk (2016) suggests that short-term memory is a working memory that corresponds roughly to awareness, or what one is conscious of at a given moment, thus implying that corrective feedback may enhance learning. Researchers agree that short-term and working memory is limited, and information could be lost if it is not transferred to long-term memory as supported by cognitive dimensions (Schunk, 2016).

There are multiple forms of correctives that may be used for a learner that provide formal and informal through formative and summative interactions. According to Sato and Loewen (2018), the most common forms of corrective feedback that are used with students are:

- oral feedback;
- written corrective feedback;
- technology-mediated feedback.

Each form subsequently allows the student to practice or resubmit work, presenting opportunities to learn from mistakes, thus providing informative information for learning (Sato & Loewen, 2018). Important to note that each form of feedback is individualized and either immediate or delayed, but all seek to facilitate effective learning.

Oral corrective feedback. Tayebipour (2019) defined oral corrective feedback as, "Teacher's [oral] provision of the correct form following an error, together with metalinguistic information [while written feedback operationalized as] the provision of [written] metalinguistic explanation to justify the correct form when an error [was] made" (p. 151). Therefore, oral feedback allows the learner to learn from corrective feedback provided through communication with the educator's support (Bacquet, 2019; Guskey, 2015; Guskey & Gates, 1986; Sobhani &

Tayebipour, 2015). Sobhani and Tayebipour (2015) elucidate the multiple forms of oral feedback represented at any given time to the learner.

Furthermore, many researchers posited that verbal feedback given in a focused manner provided the learners with significant effects in the writing abilities, suggesting that oral feedback is useful as Bloom (1968) indicates within the theories of learning (Glaserfeld, 1995; Guskey, 2007; Guskey & Gates, 1986; Schunk, 2016; Sobhani & Tayebipour, 2015). However, researchers state that the oral feedback is not usually given during the time of learning, but after and selective to the learner, and may not benefit the appropriate learning outcome at the moment the corrective feedback is needed (Sobhani, & Tayebipour, 2015; Sweigart et al., 2015; Tayebipour, 2019). Additional literature was synthesized through the notion of synchronous and asynchronous correctives later in Chapter 2.

Written corrective feedback. Written corrective feedback is a common instructional strategy used by most educators (Kang & Han, 2015). Written feedback is given to the learner in multiple forms, and the most common form is writing to a student to provide corrective measures (Gaona et al., 2018; Kang & Han, 2015). The aim is to improve student work; however, written feedback is most used in an English language arts course and not a mathematics course (Gaona et al., 2018; Kang & Han, 2015). This strategy is a commonly used strategy for asynchronous learning (Kang & Han, 2015).

Little research has equated to the use of written corrective feedback within mathematics courses; therefore, it is unclear the type of correctives for a mathematics course that would be most beneficial, thus suggesting that online platforms may provide the necessary immediate correctives to support retention and motivation; however, a teacher's perception of the online platforms providing such correctives is needed (Gaona et al., 2018; Kang & Han, 2015).

However, written corrective feedback is considered a valuable, effective strategy to provide feedback when administered within a timely manner (Sobhani & Tayebipour, 2015; Upton, 2018). Additional literature was synthesized through the notion of synchronous and asynchronous correctives later in Chapter 2.

Technology-mediated corrective feedback. Technology-mediated feedback is defined as a focus on computer tools that computer scientists and researchers have developed to provide corrective feedback to a user (Hadiyanto, 2019). The technology-mediated feedback has been used on multiple platforms, especially within the language arts classrooms. This form of feedback may provide visual technology-mediated feedback, individualized feedback, and learner–computer interactions (Hadiyanto, 2019). The corrective feedback that is mediated through technology is implicit feedback to learners. An example of a technology-mediated feedback platform would be the use of Grammarly for English learners. This platform supports speaking and writing acquisition while providing technology-mediated feedback.

A study conducted by Hadiyanto (2019) demonstrated that technology-mediated feedback in the language arts course supported that this type of feedback was better for the learners. Hadiyanto (2019) investigated whether the students that received correct feedback in their writing course through both written and technology-mediated feedback would achieve higher results.

Hadiyanto (2019) used an experimental design that had 58 student participants enrolled in the language arts course. The study provided evidence supporting the technology-mediated feedback since the students who received this type of feedback outperformed the students who received corrective written feedback (Hadiyanto, 2019). A large portion of research suggests that students who received technology-mediated feedback in language arts courses have better achievement than those who receive traditional feedback (Bacquet, 2019; Burgers et al., 2015; Dahal, 2016; Fyfe et al., 2017; Hadiyanto, 2019; Jovanović, 2019; Kang & Han, 2015). Most of the related research focused on technology-mediated feedback provides investigations that are centered around the effects of computer learning in language arts setting. However, little research has been conducted with regard to mathematics courses and technology-mediated feedback, thus exposing a gap within the literature and a need for conducting studies in this area.

Synchronous Corrective Feedback

Corrective feedback has been demonstrated to be most effective when delivered immediately; performance feedback is often provided by the teachers on a deferred schedule (e.g., the next day) (Hadiyanto, 2019; Sweigart et al., 2015). Therefore, the opportunity for learners to receive SCF through technological platforms may support student learning and retention (Collins et al., 1987; Hadiyanto, 2019; Lavolette et al., 2015). Bloom’s (1968) mastery learning theory suggests that SCF given at the appropriate time would enhance student understanding; thus, supporting meaningful learning (Chang & Yang, 2010; Evans, 2013; Fyfe & Rittle-Johnson, 2017; Guskey, 2007, 2015). Furthermore, perceptions of SCF and asynchronous corrective feedback (ACF) were noted in Shintani and Aubrey’s (2016) research with writing tasks. The research highlighted the differences between ACF and SCF, supporting student learning with SCF recall with immediate interactive feedback (Hadiyanto, 2019; Shintani & Aubrey, 2016).

Researchers posited that the approach to use SCF suggests that understanding, retaining, and recalling information through the use of cognitive strategies support student learning (Bacquet, 2019; Spyropoulou et al., 2013). Bloom’s (1968) development of cognitive taxonomy, commonly known as Bloom’s Taxonomy, enhances the cognitive development of student learning (Guskey, 2007; Spyropoulou et al., 2013). The way in which the development of learning skills focuses on the thinking domain, thus providing the learner with the opportunity to recall information due to the interactive feedback (Spyropoulou et al., 2013).

Spyropoulou et al. (2013) posited that creating learning environments that encourage students to make connections with previously learned material is an instructional design that promotes student learning. Therefore, the use of synchronous technology would support the learner as they develop the knowledge of the content. The learner is viewed as the information processor; thus, cognitive-based technology attempts to keep the learner's attention while supporting their mental activities to a new level through instructional explanations and demonstrations (Chang & Yang, 2010; Craik & Lockhart, 1972; Spyropoulou et al., 2013). Therefore, new information may be easily stored and understood (Chang & Yang, 2010; Spyropoulou et al., 2013).

Real-time Feedback. Real-time feedback aims to provide learners with frequent feedback about their performance on a given learning target (Gaona et al., 2018). In a study conducted by Gaona et al. (2018), it was found that students in a mathematic course who received immediate corrective feedback were more efficient than students who received deferred feedback. The value of immediate feedback can leverage learning and performances, thus supporting and assisting learning with accurate real-time feedback (Gaona et al., 2018). With real-time feedback, learners fully understand the context and remember key details that are given within the provided quality feedback (Bloom, 1968; Guskey, 2015; Whiting & Render, 1987). Therefore, immediate corrective feedback is beneficial for student learning (Gaona et al., 2018; Lavolette et al., 2015).

Asynchronous Corrective Feedback

Asynchronous corrective feedback (ACF) occurs after students have completed the formative assessment; the teacher provides feedback on finished material for a period of time after the students have submitted their assessments (Quinton & Smallbone, 2010). The means of ACF could be emails, verbal communication, or any means of corrections that are not immediate (Quinton & Smallbone, 2010; Upton, 2018). Akbar (2017) conducted a study that provided learners with ACF and found that learners who received ACF were lower than those receiving SCF. Further, the researchers posited that the corrective feedback induces the learner to acknowledge mistakes within the learning outcomes (Akbar, 2017). While ACF provides corrective feedback for the learner, the feedback is not immediate; thus, the learner does not receive the input with the appropriate time to make the necessary learning changes (Quinton & Smallbone, 2010; Upton, 2018). Furthermore, ACF is often overlooked or ignored by the learner due to the manner that the corrective feedback is given, ultimately affecting the desired learning outcome (Upton, 2018). ACF is the most common method of feedback that is used in mathematics courses and does not support the tenets of quality corrective feedback which relies on timeliness (Upton, 2018).

Motivation and Retention

Motivating student learning has long been problematic for educators and students. Schunk (2016) stated that retention “is increased by rehearsing information to be learned, coding in visual and symbolic form, and relating new material to information previously stored in memory” (p.125). For a student to master the learning outcomes, retention is necessary. Within Bloom’s (1968) mastery learning model, retention is imperative because the learner needs to access previously stored information for new learning to take place (Bacquet, 2019; Clark, 2018; Guskey, 2015). Additionally, Bloom (1968) provided supporting evidence that contributed to the motivation and retention of the concepts that were taught and learned (Guskey, 2007, 2015). Schunk (2016) stated that motivational behaviors are informed observers of functional value and appropriateness. Schunk (2016) indicated that consequences are motivated by creating outcome expectations and raising self-efficacy. In the following study conducted by Kazu et al. (2005), a conclusion was made that retention and motivation were evident when the researchers concluded the study.

Kazu et al.'s (2005) study was conducted with the students of a school located in Turkey. The premise of the study was to utilize the mastery learning model to answer the question, "How is it possible to remember the learned material all the time" (p. 233)? The researchers believed that Bloom's (1968) mastery learning theory would be a useful model that would allow student retention and mastery to increase (Guskey, 2007; Kazu et al., 2005). The study indicated that mastery was achieved and that students in the experimental group did indeed have a higher level of mastery, retention, and motivation (Kazu et al., 2005). Furthermore, the study concluded that students who were not in the experimental group noticed the motivation and were determined to catch up with their peer group (Kazu et al., 2005).

As the student masters the learning outcomes, self-efficacy, motivation, and retention will take place (Kazu et al., 2005; Semerci & Batdi, 2015). As motivation increases for a student, so will the level of mastery because the learner is pursuing the content that has appropriate cognitive skills and abilities (Clark, 2018; Semerci & Batdi, 2015). Finally, Semerci and Batdi (2015) posited that the learning approach that aligns with the learning theory increases the retention scores of learners. Ultimately, motivation and retention are emphasized in multiple studies promoting positive attitudes of the learners while promoting mastery (Burgers et al., 2015; Hochanadel & Finamore, 2015; Semerci & Batdi, 2015).

New Technology

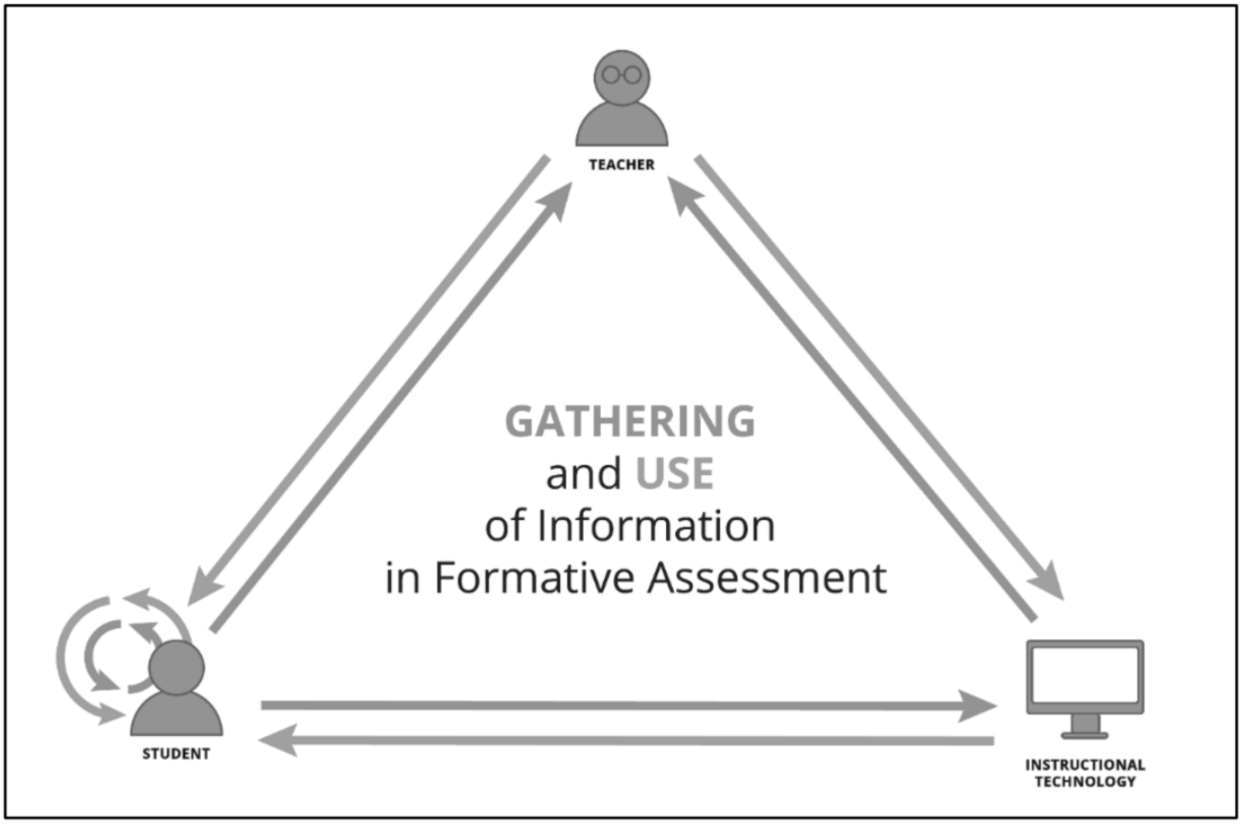
The digital world and digital intelligence have been embraced and implemented among educational institutions, educational leaders, and educators (Carrington, 2020; Guskey, 2015; Kawada, 2018; Schuetz et al., 2018). The new and emerging technologies have contributed to the increasing amount of information and advancements that are readily available for educators and students (Carrington, 2020; Kawada, 2018; Schuetz et al., 2018). Access to information is a critical indicator that has rapidly advanced education and the constant need for pedagogical shifts that provide effective teaching measures among the educators (Carrington, 2020; Guskey, 2015; Schuetz et al., 2018; Toothaker & Taliaferro, 2017). Additionally, the unforeseen emergent situation involving COVID-19 and the educational use of online learning platforms have forced educators to use such technological resources that provide learning outside of the natural classroom setting (Hussein et al., 2020).

Postman (1994) posits that adolescents have access to adult information, and digital communications open new and extensive platforms that support advanced learning (Toothaker& Taliaferro, 2017). Furthermore, Carrington (2020) marks the significance of how students interact with and engage in the world around them because of the new technology afforded to adolescents. Communication and the platforms in which educators disseminate materials or communicate is no longer a uniform process but rather a process that requires technology and technology that is rapidly advancing (Carrington, 2020; Schuetz et al., 2018; Toothaker & Taliaferro, 2017). According to Crawford (2016), despite the high quality of resources for teaching and learning, educators are choosing to approach learning through a traditional teaching model that showcases technology as an information base, not an interactive information exchange. Crawford (2016) stated that it is imperative that as new technology enhances student learning and changes education pedagogy, one must note changes in epistemologies. This is indicated with appropriate professional development and support with the rapidly evolving digital environment (Crawford, 2016; Toothaker & Taliaferro, 2017).

Online learning is at the forefront of education. The opportunity for students to learn through online platforms and with the teacher and peer interaction has been comparatively incorporated into face-to-face classrooms (Crawford, 2016). Therefore, using new technology in a blended learning environment conceptually aligns with Bloom's (1968) and Piaget's (1972) learning theories (Carrington, 2020; Crawford, 2016; Guskey, 2007; Toothaker & Taliaferro, 2017). Teachers may utilize the blended learning experiences with corrective feedback found within platforms such as Desmos to provide a blended learning approach that would facilitate seamless integration of the online platforms (Carrington, 2020; Crawford, 2016; Soltanpour & Valizadeh, 2018). With the new technologies, multiple platforms provide SCF that allows students to have corrective feedback when appropriate (Bacquet, 2019; Guskey, 2015; Soltanpour & Valizadeh, 2018). According to Crawford (2016), the experiences provided to student learning are invaluable when immediate feedback is given, ultimately increasing levels of student engagement and interest.

While new technologies and resources are easily accessible, educators should use the implementation and application of the technology with effective professional development (Crawford, 2016). Multiple studies that focus on learning to teach with new technology have granted insight to researchers about the use of new technologies within the mathematics classroom **(**Bacquet, 2019**;** Martin et al., 2017; Park, 2021; Pierce & Ball, 2009; Thomas, 2006). The case studies have provided a positive approach to using new technology from the teacher participants (Attard & Holmes, 2019; Bacquet, 2019; Ball, 2010; Park, 2021). The studies showcased the need for assessment change and curriculum change mainly due to the pedagogical differences between the traditional approach and the approach that affords new technology (Attard & Holmes, 2019; Pierce & Stacey, 2003; Toothaker & Taliaferro, 2017). Although early adopters incorporated technology into the mathematics classroom within the studies, none of the technology focused on corrective feedback, instead the use of new technology in the mathematics classroom and the implementation of such technology (Attard & Holmes, 2019; Pierce & Stacey, 2003). Furthermore, exploring the need to design assessments that would enhance the use of the technology is noted within the research (Attard & Holmes, 2019; Bacquet, 2019; Pierce & Stacey, 2003; Thomas, 2006; Ball, 2009; Toothaker & Taliaferro, 2017). Figure 3 demonstrates the flow of information that uses instructional technology to mediate formative assessments. Furthermore, it is noted that technological platforms that reference feedback focus on teachers using a new approach to process feedback to students to improve student learning.

Figure 3.



Note. This flow chart was produced by Bush in 2020, demonstrating technology mediated through instructional technology. From "Technology Mediated Formative Assessment: How Instructional Technology Supports Teaching and Learning Mathematics," by J.B. Bush, 2020, *[Doctoral Dissertation]*.

Synchronous Technology. Synchronous technology is an online platform that provides a learning environment that may provide opportunities for learners to be active with their teachers or peers while learning a specific concept which is noted in Piaget's (1972) cognitive learning theory (Beldarrain, 2007; Khan, 2015; Kutaka-Kennedy, 2015). Researchers Martin et al., (2017) defined synchronous online learning as:

> (a) permanent separation (of place) of the learner and instructor during planned learning events where (b) instruction occurred in real-time such that (c) students were able to

> communicate with other students and the instructor through text-, audio-, and/or video-based communication of two-way media that facilitated dialogue and interaction (p. 5).

Additionally, technology may allow for rapid changes or work with data that simultaneously updates as the participant completes tasks (Attard & Holmes, 2019; Kutaka-Kennedy, 2015). Synchronous technology may foster collaboration and immediate learning of concepts in the learning environments (Beldarrain, 2007; Kutaka-Kennedy, 2015; Martin et al., 2017). The critical thinking skills found in Bloom's (1971) taxonomy and mastery learning promote creativity and collaborative work, which support learning retention and motivation through the advanced technologies offered through innovation (Attard & Holmes, 2019; Guskey, 2007; Kirkwood & Price, 2014; Kulik et al., 1990; Kutaka-Kennedy, 2015; Martin et al., 2017). Palocsay and Stevens (2008) found that technology can simplify the creation and grading of assignments and provide opportunities for assessment testing, thus providing students with skill level opportunities to respond to appropriate and efficient learning. Additionally, Lavolette et al. (2015) stated that the effectiveness of synchronous feedback through technology is immediate and beneficial for students rather than delayed feedback. Online platforms that provide synchronous feedback as the learning is taking place that provides the real-time corrective feedback. The online platforms could be Desmos, IXL, Khan Academy, Google Docs, Udemy, Courseara, Elluminate, Blackboard Collaborator, Udacity, and Skillshare. Using such platforms that provide SCF as the learning is in the formative process may increase the overall retention and cognitive awareness of the intended learning (Martin et al., 2017). This research study followed the use of Desmos, Google Docs, and IXL's corrective feedback features.

Desmos. There are a variety of platforms that provide corrective feedback to the learning process; therefore, Desmos is what this study will use to guide the implementation of corrective feedback. Desmos and IXL are noted for allowing students to learn by doing and instantly seeing changes to their graphs or manipulating values. Desmos researchers promote the platform as thoughtfully designed and deeply collaborative so that the application of problem-solving and creatively applying what the students learn may be enhanced as the learning process progresses (Desmos, 2021). Furthermore, Desmos (2021) stated that the design code folds in our collective understanding of mathematics, identity, culture, curriculum, cognition, and pedagogy, thus fitting the theoretical framework and the basis of this collective case study.

International Teaching

Many international Christian schools are located in Asia. This study will utilize an international school located in Taiwan. Taiwan is a small island beside China, below Japan, and about an hour flight from Hong Kong. According to the National Center on Education and Economy (NCEE) (2021), Taiwan's mathematics and science performances are among the top of all participating countries. Taiwan welcomes the international community to support the educational system and has seen an increase of international students in the higher education sector (Magaziner, 2016).

The compulsory educational system begins at the primary level, at age six. Primary subjects include Mandarin, mathematics, science, English, native languages, social studies, homeland education, music, and art. Junior high school lasts three years, from grades 7 through 9. Junior high students may pursue either an academic or vocational track. Three years of senior high school are mandatory for Taiwanese students. The senior high school extends from grades 10 through 12. It includes either an academic track or a vocational track (Magaziner, 2016). International schools follow the system that the institution is based on, and for this study, the

United States educational system is the primary system that is followed. The students enrolled in an international school are required to have a foreign passport.

Summary

Chapter Two included vital elements for this collective case study. The theoretical framework of Bloom's (1968) mastery learning theory and Piaget's (1972) cognitive learning theory were used to guide this study (Guskey, 2007). The problem was stated, the theoretical framework was discussed, and relevant literature supporting student learning while using correctives feedback was addressed. Specifically, the Chapter elucidated the use of Bloom's (1968) mastery learning theory that suggests the use of correctives is key to student learning; furthermore, the recent research indicates that immediate corrective feedback aligns with Bloom's (1968) theory supports the learners cognitive process thus supporting the cognitive learning theory (Brookhart et al., 2016; Guskey, 2007, 2015; Piaget, 1972). Specific attention was given to the rapid advancement of technology, and educators are increasing the opportunity to utilize resources to support student learning and retention (Beldarrain, 2007; Burgers et al., 2015; Kirkwood & Price, 2014).

Comparing SCF and ACF with mathematical students may be beneficial for student learning, thus providing an effective teaching method for educators. The literature and research suggest that Bloom's (1968) mastery learning theory is supported with data specifically for student learning through the use of correctives (Guskey, 2007). Still, the data has not been gathered for high school mathematics courses, specifically the perceptions of the mathematics teachers that may implement and utilize the online platforms that provide the SCF. SCF occurs in an online computer-mediated environment where the teacher provides CF while students are in the process of completing their mathematical assessments. ACF takes place after students have completed the formative assessment; the teacher provides feedback on completed material for a period of time after the students have submitted their assessments.

This collective case study may fill this research gap and provide researchers and educators with an understanding of how synchronous real-time feedback through an online platform may enhance student learning in high school mathematics courses, thus promoting retention and motivation of the learning outcomes as shown with the Piaget's (1972) cognitive learning theory (Whiting & Render, 1987). The theoretical proponents support the innovative approach, thus providing an opportunity of closing the learning for mastery gaps and providing an understanding of how online platforms may support student learning for mastery, as Bloom (1968) suggested through the research and theory (Guskey, 2007). Additionally, Piaget's (1972) cognitive learning theory that provides the basis of processing information would illuminate the enhanced use of technology to support the student learning process (Whiting & Render, 1987). Due to the rapid advancement of online platforms, research must be conducted to understand the perceptions of high school mathematics teachers that utilize synchronous platforms that provide real-time corrective feedback that fit within the mastery learning framework. Additional research is needed to explore a teacher's perception of the use of online synchronous learning platforms in the mathematics classroom. This research study provided an understanding of the gap in the current literature regarding a teacher's use with online platforms that provide synchronous corrective feedback within high school mathematics courses.

CHAPTER THREE: METHODS

Overview

The purpose of this collective case study was to present an in-depth understanding of teachers implementing and using online synchronous technology that provides real-time corrective feedback for students in a high school mathematics course located at three international high schools in Taiwan. This collective case study explored themes and data from mathematics teachers' implementation process of synchronous technology from the three schools. Chapter Three highlights this study's research design, participants and setting, data collection and analysis procedures, the researcher's role, and ethical considerations.

Research Design

The qualitative methodology focusing on a collective or multi-site case study design guided this research (Yin, 2018). The phenomenological, narrative, and ethnography are qualitative inquiry methods; however, the collective case study method is the best approach because it allows for cross-case analysis that provides an in-depth, rich collection of empirical data that connects to the study's research questions and the study's conclusions (Creswell, 2017; Yin, 2018). Yin (2018) suggested using a collective case study research design when a phenomenon is examined among multiple settings. Furthermore, the collective case study approach provided a complete understanding of the situation and an extensive analysis of the real-life phenomena (Creswell, 2017; Gustafasson, 2017; Yin, 2018). Collective case study design provided an in-depth analysis of data within each situation and across different situations (Yin, 2018). Yin (2018) suggested that evidence from a collective case study is more compelling because of direct replication. Additionally, I studied multiple cases to understand the differences and similarities between the cases within this study (Yin, 2018).

This collective case study research design examined high school mathematics teacher's implementation and usage of online synchronous technology at three international schools in Taiwan. The school is one system but is comprised of three campuses. The cases for this collective case study were the three schools within the system and the teachers were the embedded units of analysis (Yin, 2018). Using within-case analysis and cross-case comparison of the high school mathematics teachers increased reliability and validity by providing various experiences that conclusions were drawn from (Yin, 2018). Further, the qualitative design allowed for changes because of the participants' information during the research process (Creswell, 2017; Yin, 2018). This allowed me to conduct a cross-case analysis to synthesize the shared experiences of selected teachers, and finally, a lessons-learned approach across the cases to derive the naturalistic generalizations (Yin, 2018).

The theoretical framework for this qualitative study was based on Bloom’s (1968) mastery learning theory and Piaget’s (1972) cognitive learning theory (Guskey, 2007). These theories informed the central research question and sub-questions while addressing the research problem (Creswell, 2017; Yin, 2018). This study used Bloom’s (1968) mastery theory and Piaget’s (1972) cognitive learning theory to ultimately understand the problem of the resistance to use SCF because it is unknown if it has a positive or negative influence among high school math students (Guskey, 2007).

The study was conducted at an international school in Taiwan within three separate campuses. The interviews and data received allowed for extensive analysis of the participant's experiences implementing and using real-time corrective synchronous feedback (Creswell, 2017; Gustafasson, 2017). This approach comprehensively understood the participant's experiences with the platforms and corrective feedback in the high school mathematics course. Throughout this study, multiple forms of data were collected: (a) interviews, (b) observations, and (c) focus groups. Data gathered from these methods were analyzed, allowing for triangulation of the study's data and validity (Yin, 2018).

Research Questions

The research questions that guided this collective case study included one central research question and two sub-questions. Each question was grounded in Blooms (1968) mastery learning theory and Piaget's (1972) cognitive learning theory and literature that has been reviewed (Guskey, 2007).

Central Research Question

How do high school mathematics teachers implement and use online learning platforms that provide real-time corrective feedback?

Sub-Question One

How do high school mathematical educators describe their interactions with synchronous platforms that provide real-time corrective feedback?

Sub-Question Two

How do mathematics teachers perceive the support level of synchronous, online corrective feedback in high school mathematic courses?

Setting and Participants

The following provides an overview of the site and participants within this research study. The site for this collective case study was based on the case itself and was consist of the teacher's natural context (Yin, 2018). The participants were teachers identified through purposeful, criterion sampling (Yin, 2018).

Site

This collective case study occurred in Taiwan at an international school. The school has one system comprised of three campuses located in Taipei, Taichung and Kaohsiung. Additionally, the school is jointly accredited school with the Association of Christian Schools International (ACSI) and the Western Association of Schools and Colleges (WASC). Amongst the three schools, there are 189 faculty members in total. These faculty members consist of 154 full-time employees and 35 part-time employees. Additionally, 49% of the educators hold bachelor's degrees, 48% hold masters, and 3% have a doctorate-level degree. There are approximately 930 students enrolled throughout the three campuses. There are 35 nationalities represented throughout the student body. The school's demographic representation is consistent with high economic status, and 99% of the students attend university upon graduation. The data gathered that students who leave this academic institution obtain either pre-med or engineer degrees was quite significant.

The three campuses' representation comprises a System Administrative Committee (SAC) and has an administrative representative from each campus and the support services. The Support Services (SS) is derived from the superintendent, director of learning, finance director, director of boarding, human resources, and technology director. Additionally, the SS houses all data analysis and implementation of new projects and curriculum. The principals from each campus represent the campus at the SAC level. The final governance is through the mission-directed board. All initiatives, policies, procedures, and selection of administrative staff must seek board approval.

Morrison Academy Taichung is one location that was used to gather information from teachers. The Taichung campus is a Kindergarten to Grade 12 institution. The campus administrative structure was comprised of two principals, two learning coaches, team leaders, and department heads. One principal is primarily responsible for the elementary and middle school, and the second principal is responsible for the high school. The information for this collective case study was gathered from the high school mathematics teachers.

Morrison Academy Kaohsiung is another site that provided information from the school's teachers. The Kaohsiung campus is a Kindergarten to Grade 12 institution. The campus administrative structure is comprised of one principal, two learning coaches, and team leaders. The information for this collective case study was gathered from the high school mathematics teachers.

Morrison Academy Taipei is the third site that provided information from the school's teachers. The Taipei campus is a Kindergarten to Grade 12 institution. The campus administrative structure is comprised of one principal, one learning coach, and team leaders. The information for this collective case study was gathered from the high school mathematics teachers.

This school system was used because of the implementation and innovative resources within the academic courses. Additionally, the international setting was close to me, allowing for increased time for data collection.

Participants

The type of sampling for this study was purposeful sampling, which was based on the assumption that the researcher wants to discover and gain insight (Creswell, 2017; Patton, 2015; Yin, 2018). Additionally, purposeful sampling was used to determine the teacher participants, which are the embedded units of analysis (Yin, 2018). Patton (2015) posited that criterion-based selection is used by making a list of attributes related to the purpose of the study that will serve as a guide to identifying information-rich cases. The purpose of this current collective case study was to present an in-depth understanding of teacher's experiences implementing and using online synchronous technology that provided real-time corrective feedback for students in a high school mathematics course at an international school in Taiwan; this purpose served as a guide to determine the participant selection criteria.

The sampling solicited 12 educators from the mathematical departments at the three schools. My study resulted in three participants withdrawing from the study because they could not fulfill the participation requirements. As a result, nine participants completed the study. The criteria for selection were that the educator must teach a high school mathematics course, have a teaching certification from a state or recognized accredited agency, and used the online platform as a resource for one mathematics unit. A series of demographical questions such as age, gender, and ethnicity, followed by personal questions about teacher certification, were included in a demographical survey (Appendix F). The demographical information was gathered using a Google Form. After permission was received to conduct the research and approval from the IRB, this study was conducted at the three sites. I contacted the mathematical educators who teach high school courses and were not under the researcher's authority. The participant gender, race, years of experience, highest degrees earned, content area, and grade levels taught are presented in Table 1 below.

Table 1

Participant Demographics

Teacher participant	Gender	Race	Years taught	Highest degree earned	Content area	Grade level
Brandon	Male	Asian	15+	Masters	Algebra 2	9-12
Mike	Male	Caucasian	5-10	Bachelors	Geometry	9-12
Ray	Male	Asian	5-10	Bachelors	Algebra 1	9-12

Sally	Female	Asian	15+	Bachelors	Algebra 1	9-12
Sam	Male	Asian	15+	Masters	Algebra 1	9-12
Tom	Male	Caucasian	15+	Masters	Algebra 1	9-12
Charlotte	Female	Asian	10-15	Masters	Algebra 1 & Algebra 2	9-12
James	Male	Asian	0-5	Masters	Geometry	9-12
Mary	Female	Asian	10-15	Masters	Pre-Calculus & AP Statistics	9-12

Researcher Positionality

The motivation to conduct this study was to promote student learning while prescribing to Bloom's (1968) mastery learning theory and Piaget's (1972) cognitive learning theory through the opportunity to utilize the advancement of technology to increase student learning and to encourage the use of implementing technological resources that provide SCF with educators (Guskey, 2007). The need for a pedagogical shift with many educators was evident and one that encapsulates the use of corrective feedback. Although online SCF may be overwhelming for some educators, it may be a relief that a platform that provides real-time corrective feedback is available. The relief may be through the promotion of learning and retention that supports student learning because of the immediate corrective nature.

Interpretive Framework

As someone who values multiple perspectives, I realize that numerous realities are constructed by living experiences and interacting with others. Although the positivist research approach has multiple assumptions, this study utilized the constructivist paradigm. This approach allowed for understanding and knowledge of the experienced problem to illuminate from the reflections and experiences of the study's participants (Patton, 205). The use of individual interviews and focus groups allowed the participants to respond extensively to the research and provided answers that benefited the collective case study. In addition, I aimed to produce significant knowledge that could be useful to educators and educational leaders due to my inquiry into the teacher's experiences (Patton, 2015).

Philosophical Assumptions

In this collective case study, the philosophical assumptions corresponding are epistemological, ontological, and axiological (Creswell, 2013; Creswell & Poth, 2018). The participants' views were valuable for this research, thus the epistemological assumptions presented by the educators (Creswell & Poth, 2018). Educational practices are promoting collaboration, creative and critical thinking skills; therefore, allowing a student to learn with a platform that provides real time corrective feedback may support the educational components (Carrington, 2020; Guskey & Jung, 2015). As the educator considers their student’s diverse backgrounds, cultures, traditions, and learning needs that are represented, they should understand the individuals purposeful design leading the educator to a differentiated approach thus utilizing technology to support learning (MacCullough, 2012; Sire, 2009).

Ontological Assumption

The perceptions of the researcher and the participants were central in the research because each individual had a different perspective from one another, thus providing the ontological assumptions, which relate to the nature of reality or realities (Creswell, 2013). This perspective viewed the participants as a valuable individual and important to the research process.

Epistemological Assumption

The epistemological stance used for this study was constructivism. Constructivism is a theory that says learners construct knowledge as they experience the world rather than passively taking in information (Schunk, 2016). The participants' views were valuable for this research, thus the epistemological assumptions presented by the educators within the study (Creswell & Poth, 2018). The researcher was trying to find answers to the research questions by presenting the impact that online synchronous technology that provides real-time corrective feedback had on student learning that utilizes teacher's interactions with online platforms.

Axiological Assumption

The influence the research had within the findings' interpretation must be minimized, thus exposing the values and principles that provided my axiological assumption (Creswell, 2013). However, I am an educator that is passionate about student learning, teacher professional development, and innovative, effective teaching practices. Therefore, the awareness of biases present within this study are due to the relational context within the researcher's role and the interpretation in conjunction with the participants. This may constitute a bias; however, it is openly acknowledged that biases are present.

Researcher's Role

I fully understood that they were serving as an observer and as the primary human data collection instrument within this research study (Creswell, 2017). I have been a teacher for nearly two decades and have taught multiple grade levels within the kindergarten to the twelfth-grade sector. Currently, I am a professional learning coach for the site and work with elementary and middle school teachers. I have conducted professional learning workshops for the participants and have a professional relationship, but had no direct supervision over the high school mathematics departments or educators. A detailed description of the potential bias of the analysis is described herein (Creswell, 2017).

All discussions and interviews followed the semi-structured protocol suggested by Creswell (2017). While eliminating all of the personal bias is impossible, it is openly acknowledged the potential for bias, thus, increasing the trustworthiness of the research study (Galdas, 2017; Yin, 2018). Critically examining my role and knowing that through this qualitative research approach it is an integral part of the final product and process thus separating personal indications is not desirable or possible; however, a transparent and reflective approach that guides the collection, analyzation, and presentation of data was critical (Galdas, 2017). Additionally, asking questions in a leading manner or carefully noting not to bring personal emotions into the interviews was of utmost importance to me (Creswell, 2017; Yin, 2018).

Procedures

The following provides an explanation that includes necessary site permissions, information regarding Institutional Review Board (IRB) approval, soliciting participants, the data collection and analysis plans by data source, and an explanation of how the study achieved triangulation.

Permissions

The school's superintendent was contacted through email (Appendix A) so that permission may be granted to conduct research. Before collecting data, I secured Liberty University (LU) IRB approval (Appendix C). A letter was sent to the school's superintendent and the campus-specific high school principal. Site approval was requested and given by the campus-specific principal (Appendix B). After site approval from the education institution, the researcher contacted the mathematics educators through email with a recruitment letter (Appendix D), and official participant consent was obtained (Appendix E). Once consent was obtained, data collection began (Appendix G, Appendix H and Appendix I). Interviews and observations were scheduled. Due to Covid restrictions, all interviews took place through Zoom. The interviews were recorded and transcribed using pseudonyms to protect participant identity (Creswell, 2017). A copy of the recruitment letters and LU's IRB Approval Letter, are included in the appendices of this study.

Recruitment Plan

The type of sampling for this study was purposeful criterion sampling (Creswell, 2017; Patton, 2015; Yin, 2018). Creswell (2017) defined criterion sampling as purposefully informing an understanding of the research problem and central phenomenon in the study with a particular subset of people. The purposeful sampling method was appropriate for this study because the participants were experiencing the phenomenon that was being studied (Creswell, 2017; Yin, 2018). The sampling solicited 12 educators; four were participants from each mathematical department at the three sites. The criteria for selection were that the educator must teach a high school mathematics course, hold a teaching certification from a state or recognized accredited agency, and have used the online platform as a resource for one mathematics unit. After permission was received to conduct the research and approval from the IRB, this study was conducted in the three locations of an international school in Taiwan. I contacted the mathematical educators who were teaching high school courses and were not under my authority.

Data Collection Plan

Data was collected for this study using individual interviews, observations and focus groups (Patton, 2015; Yin, 2018). All of the gathered data was securely stored (Creswell, 2017; Patton, 2015). The following describes each of the data collection methods.

Individual Interviews

The primary method of data collection was through semi-structured participant interviews (Appendix F). The interviews provided vital information for the gathering of evidence for this study. All participants were asked the same open-ended questions and followed the semi-structured approach (Creswell, 2017; Yin, 2018). The open-ended questions were used so that additional questions could be asked during the interviews (Yin, 2018). The responses formed the most substantive data collection method.

The interviews took place using an online conferencing platform and was scheduled at the participants convenience. The interviews were scheduled for a one-hour timeframe. Additionally, the conversations were recorded and transcribed verbatim while using pseudonyms for each of the participants (Creswell, 2017). In response to Covid-19 requirements for social distancing, all interviews and focus-group discussions occurred over video chat.

Individual Interview Questions

1. How would you describe your ways of providing feedback to your students? (CRQ)
2. How often do you use computers during class lessons? (CRQ)
3. What math platforms do you ask your students to utilize during a unit? (CRQ)
4. What is your current method to provide corrective feedback to your students? (SQ1)
5. How do you think online synchronous platforms such as Demos providing real-time corrective feedback differ from you providing corrective feedback to your mathematical students? (SQ1)
6. Please describe, with as much detail as possible, how the online platforms support your student’s learning. (SQ1)
7. How were your students engaged in the learning content when they were using the platform? (SQ1)

8. Describe how the online platform was implemented. (CRQ)
9. What professional development experiences have you had that prepared you to work with online mathematics platforms as a teacher? (SQ1)
10. What changes would you want to make to the platform or training that you received? (SQ2)
11. What else would you like to add to our discussion of your experiences with corrective feedback or online platforms that we haven't discussed? (CRQ)

Questions one through four were designed to understand the participant's view of the mastery learning theory and the use of corrective feedback (Bloom, 1987; Guskey, 2007, 2015; Guskey & Jung, 2012). Questions five through 11 were phrased explicitly to collect perception data about synchronous technology in the classroom (Lavolette et al., 2015; Quinton & Smallbone, 2010; Spyropoulou et al., 2013).

Individual Interview Data Analysis Plan *(Data Analysis Plan #1)*

I took both descriptive and reflective notes throughout each interview. To ensure that all data collected was recorded appropriately, all questions, insights, and hunches were recorded immediately following each interview (Creswell, 2017; Yin, 2018). The interviews were transcribed verbatim. Once the interviews were transcribed, I sent the transcript to the participant for member checking. I read all of the transcripts thoroughly, make notes about impressions, and identifying common themes (Yin, 2018). Seeking a collection of themes from the data provided relevant meaning about the lessons learned from each case (Saldaña, 2013; Yin, 2018). Reading and rereading the data to identify concepts, themes, and patterns in the narrative was part of qualitative coding (Yin, 2018). The codes emerged throughout the coding process. The

Qualitative Data Analysis Software, MAXQDA 2022 was used to support the data analysis process.

For this study, I annotated the transcripts and labeled relevant words, phrases, sentences, or sections with codes that were noted through pattern matching using MAXQDA 2022 (Yin, 2018). The data was categorized by raw data, interpretation, and personal reflections (Creswell, 2017; Yin, 2018). Additionally, I established the connection to categories, and the connections were described (Yin, 2018).

Within-case Analysis

I analyzed the rich data descriptions from each case within this study. This allowed themes and patterns to appear through each case's data analysis procedure (Yin, 2018). Data gathered from the participants was analyzed using within-case and cross-case analysis procedures (Yin, 2018). I followed within-case analysis procedures to establish general themes to each case (Creswell, 2017; Yin, 2018).

Cross-Case Analysis

I repeated the steps listed above for all interviews, and cross-case observations were made as suggested by Yin (2018). I continued examining data by synthesizing commonalities across cases (Yin, 2018). Stake (2006) proposed the incorporation of research worksheets as an organizational structure throughout the analysis process. Then, I created Research Question Worksheets (Appendix I) for use within the data analysis process. The research questions were listed within the chart. Next, I completed the Notes Worksheet (Appendix J) that was used during the data collection. I created one Notes Worksheet for each case to assist with the development of codes. I developed a Merge Findings Worksheet (Appendix K) to support the recording of results. Stake (2006) proposed using an Assertions Worksheet (Appendix L) for the cross-case analysis phase. Finally, I used the Assertions Worksheet to support groupings of the assertions as they related to the research questions.

Observations

Observational research allowed me to visit the field and take field notes on the behaviors at the research site (Creswell, 2017). Data from observations allowed me to triangulate what the participants said and validate views that were expressed to gather additional data for each case. The information collected through observations provided firsthand experience with the participants (Creswell, 2017). Observations were recorded using field notes protocol (Appendix H) as Creswell (2017) listed. The central research question and research sub-questions were addressed by observations conducted within each case. The observations provided me with valuable aspects that pertained to the research that participants did not articulate in the interviews (Creswell, 2017).

Direct observations in the high school mathematics teacher's classrooms were conducted, and I was a non-participant observer. Observation field notes were typed and provided information that was supplemental to data collected through the additional data collection methods (Yin, 2018). The observational notes provided both descriptive and reflective information (Creswell, 2017).

Observation Data Analysis Plan *(Data Analysis Plan 2)*

I observed the teacher's interactions with the online platforms used within the high school mathematics classroom. This plan ensured that I provided coherence between this study's research questions and themes that emerged from the individual interviews. To maintain a chain of evidence and to develop themes that emerged from the data, I used observational notes. Creswell (2017) suggested that the notes be divided into categories, and for this study, the notes were divided into two categories (Appendix H). The descriptive information provided details that represent factual data for each case. The reflective data was the researcher's thoughts, questions, or ideas during the data collection process (Creswell, 2017). The observational field notes were copious. I documented site experiences, observed demographics and each participant as the online platform was utilized within the classroom setting.

After the observations, the observation notes were analyzed using a themes table and coding. Carefully taken notes assisted in categorical aggregation, which was useful in establishing themes and patterns for analysis (Creswell, 2018). The lessons learned emerged through themes and patterns and those were used to analyze within-case and cross-case data to provide relevant meaning from the cases (Saldaña, 2013).

Focus Groups

According to Patton (2015), focus groups are types of interviews that have multiple participants with the objective of getting high-quality data in a social context. For this study, I conducted one focus group at each school involving the teacher participants. The focus group allowed the participants to collectively describe their implementation perceptions and experiences within the context of this study's topic. The focus groups enabled within-case data analysis to occur.

Cross-Case Analysis

There was a second focus group. The focus group consisted of one teacher participant from each school campus. I identified one candidate from each campus, and the selection occurred after the individual interviews. This allowed me to do cross-case analysis that served as part of the data triangulation. These focus groups served as an opportunity to provide varying perspectives on the data that was gathered from the initial interviews and observations (Patton, 2015). I hosted the focus group meetings through an online conferencing platform, and it was recorded. The following were the Focus Group Interview Questions for the session (see Appendix G).

Focus Group Questions

1. How would you describe your ways of providing feedback to your students? (CRQ)
2. How has technology provided opportunities for you to provide real-time synchronous feedback to your students? (SQ1)
3. Describe the successful practices you use when working with the online platforms in your math classes. (CRQ)
4. What professional development experiences have you had that prepared you to work with online platforms that provide corrective feedback? (SQ2)
5. What else would you like to add to our discussions of your experiences with implementing SCF? (SQ2)

Questions one and two were designed to give data on the corrective feedback provided through technology (Bloom, 1968; Yin, 2018). Question three was designed to give data about the implementation process. Question four was designed to provide data about the professional development experiences that the participants have experienced. Question five was the ending question that allows for additional comments that were not addressed during the previous questions (Patton, 2015). The focus groups were transcribed verbatim. Remaining committed to the questions will avoid reflexivity.

Focus Group Data Analysis Plan *(Data Analysis Plan #3)*

Prior to conducting the focus group, data was collected and analyzed from each individual interviews and observations. The initial individual case and cross-case analysis through the completion of the Merged Findings Worksheet (Appendix K) was completed prior to conducting the focus group. The focus groups were video-recorded and transcribed for theme development. The initial step of the data analysis process was to transcribe the focus group interviews into a written format. This allowed me to continue developing themes that emerged from the data and provided relevant meaning to the lessons learned from the cases (Saldaña, 2013). The focus groups gathered data through group discussions based on the participants' perceptions and experiences (Creswell, 2017; Yin, 2018).

The data were stored in one central location providing me with concepts, patterns, and insights into the collected data (Yin, 2018). All transcripts were read through multiple times and the participant responses were used for coding and theme production. Pattern matching was used to compare resulting themes. The themes were analyzed as a consensus or shared view throughout the group discussion (Yin, 2018).

Data Synthesis

The fundamental goal of qualitative research is to use the data analysis to determine patterns, themes, provide answers to research questions, and report findings and conclusions (Patton, 2015; Saldaña, 2013; Yin, 2018). Data analysis occurred by understanding the participant's views, observing the participant's behaviors, and examining the elucidated implications (Creswell, 2017; Patton, 2015; Saldaña, 2013). This study analyzed data through interviews, observations and focus group interviews. This allowed for the process of dissecting the data and extracting pertinent statements from the data collection process (Yin, 2018). The data analysis procedures for this study provided detailed-rich descriptions of the cases (Creswell, 2017; Creswell & Poth, 2018). For this study, I conducted individual case analysis on each case followed by cross-case analysis of the cases to look for similarities and differences between the cases (Stake, 2006).

Coding

Identifying patterns within research is one method of data analysis. Saldaña (2013) posited that using structural coding is useful for the semi-structural interview protocol. I used this approach within this case study. The development of themes and then extricating codes to create a thorough understanding of the data was followed (Saldaña, 2013; Stake, 2006). The steps involved identifying patterns through direct interpretation of individual texts of data and categorical aggregation of multiple pieces of data. The patterns that emerged from this analysis resulted in codes that were categorized, combined, and refined to present an in-depth view of each case. Color coding the interview transcripts provided support for the coding process.

With-in Case Synthesis

Data analysis for this collective case study included preliminary analysis, pattern matching, and thematic generalizations within each case (Creswell & Poth, 2018; Yin, 2018). Reading and rereading the data to identify concepts, themes, and patterns in the narrative is part of qualitative coding (Yin, 2018). The direct interpretation established the general themes, and categorical aggregation provided meaning and patterns within the data (Yin, 2018). Patterns within each case lead me to develop specific codes that were classified into themes (Yin, 2018). Once the preliminary coding was complete for each case, the list of codes was combined, categorized, and adjusted to present a holistic description of each case.

Field notes and memos were used during the data collection to note code development through the process. To assist in this process the Qualitative Data Analysis Software, MAXQDA 2022, was used to support the coding process. MAXQDA 2022 organized the development of themes that I used to establish confidence and trustworthiness of the research findings (Creswell & Poth, 2018).

Cross-Case Synthesis

The cross-case analysis incorporated an organization structure of the data that Stake (2006) proposed through a series of worksheets. I created Research Question Worksheets (Appendix I) for use within the data analysis process. The research questions were listed within the chart. Next, the researcher completed the Notes Worksheet (Appendix J) that was used during the data collection. I created one Notes Worksheet for each case to assist with the development of codes. I developed a Merge Findings Worksheet (Appendix K) to support the recording of results. Stake (2006) proposed using an Assertions Worksheet (Appendix L) for the cross-case analysis phase. Then, I used the Assertions Worksheet to support groupings of the assertions as they related to the research questions. Naturalistic generalization guided the interpretation of the data (Yin, 2018).

Trustworthiness

The trustworthiness of qualitative research can be demonstrated in multiple forms. The demonstration of trustworthiness through steps to increase the credibility, dependability, and transferability authenticated this study's findings (Creswell & Poth, 2018). This section provides an explanation and description of the procedures that I took to ensure the trustworthiness of the research study.

Credibility

The validity of the data within a study is known as credibility (Yin, 2018). The triangulation strategies employed within the study were member checking, detailed, thick descriptions, clarifying biases, and peer debriefing. This provided the research study with credibility (Creswell & Creswell, 2018). Triangulation occurred through the data collection, which were the interviews, observations and focus groups (Creswell, 2017; Yin, 2018). All participants were asked to ensure the accuracy of the transcripts and data analysis after the interviews were completed, thus providing credibility through member checking (Creswell, 2017). Informing the readers of any biases present within the study was clarified and included in the study (Creswell, 2017).

Transferability

The rich, thick, detailed descriptions that were given provide transferability and the framework for using this study in other settings (Creswell & Poth, 2018). The detailed accounts within each case, the focus of the study, the researcher's role, the position, and the bias were noted (Creswell & Poth, 2018). The data collection and analysis strategies were reported in detail so that researchers can replicate an accurate picture of the methods used within this study (Creswell & Poth, 2018). Finally, the research and phases of the study were peer-reviewed by a qualitative specialist (Creswell & Poth, 2018).

Dependability

Dependability was critical to the reliability of this collective case study (Creswell & Poth, 2018). Checking for consistency and dependability with the gathered data was necessary and completed through various strategies (Creswell & Poth, 2018). Using a peer review method to check the data for bias and inaccuracies was employed (Creswell & Poth, 2018). Additionally, sharing the data with the participants involved in the research ensured that the information is accurately portrayed and served as dependability for the study (Creswell & Poth, 2018). Finally, I utilized an audit trail to support the study's dependability (Patton, 2015; Yin, 2018). The audit trail provided in-depth narratives from the participants, examined the data collection and data analysis (Patton, 2015). The use of transcriptions and field notes supported the trustworthiness of this study (Creswell & Poth, 2018).

Confirmability

The research was grounded in literature and theories, which ultimately assists confirmability (Creswell & Poth, 2018; Yin, 2018). Yin (2018) articulated the importance of confirmability; therefore, this study provided all components of research grounded in literature, thus providing citations for the literature that supports the research purpose and design (Creswell & Poth, 2018). Additionally, a detailed audit trail is provided. The audit trail includes procedures, raw data, analyzed data, and a final report.

Ethical Considerations

I completed LU's IRB process, and all approval and site approval were granted before the recruitment of participants began. An agreement of confidentiality of the participants and location was taken, and the researcher only used pseudonyms. The participants were informed of the consent and the right to withdraw from the study at any time during the study. The gathered digital data, recorded interviews, and all electronic files were secured and password protected on a portable hard drive. Physical documentation was secured in a locked cabinet. The files were kept for two years, after which the researcher will destroy the content.

Summary

Patton (2018) explained that the case study design is one of the most challenging methods for qualitative research. However, case study research highlights the solid and rich data that is illuminated during the fieldwork (Creswell & Poth, 2018). Highlighted throughout Chapter Three were the collective case study design elements. Additionally, this chapter provided the methodological framework for this qualitative research study investigating the understanding of teachers implementing and using online synchronous technology that provides real-time corrective feedback for students in a high school mathematics course at a Christian school in Taiwan. Finally, Chapter Three elucidated the research design, questions, setting, participants, sampling methods, data collection, the process to ensure trustworthiness, and ethical considerations.

CHAPTER FOUR: FINDINGS

Overview

This collective case study aimed to present an in-depth understanding of teachers implementing and using online synchronous technology that provides real-time corrective feedback for students in a high school mathematics course located at three international high schools in Taiwan. The collective case study explored themes and data from mathematics teachers' implementation process of synchronous technology in the three schools. The study specifically focused on how high school mathematics teachers implemented and used online learning platforms that provide real-time corrective feedback, how they interact with the platforms, and how they perceive the support from the institutions with the online platforms. Chapter Four includes participant descriptions, data related to the themes, and responses to the research questions, and finally, the chapter finishes with a summary of these findings.

Participants

The participants include high school mathematics teachers that shared their experiences with the implementation of the mathematics platforms from each site. In order to preserve the identity of all of the participants, pseudonyms were given and listed in the demographics table. There were three female participants and six male participants. Two of the participants were Caucasian and seven were Asian.

Results

This study aimed to provide an understanding of how high school mathematics teachers implemented online platforms that provided real-time corrective feedback. Patterns within each case were discovered, and a cross-case analysis was conducted (Stake, 2006). Each case was analyzed by reviewing individual interviews, observational data, and focus group data (Stake, 2006). Triangulating findings across the cases led to noticeable patterns among the cases. These findings supported the final assertions development. The within- and cross-case analyses of the data provided significant answers to the central research question and two sub-questions.

This section displays the results of the data analysis process using quotes from the participants. The following table identifies all themes and sub-themes identified in the findings.

Table 2

Theme Development

Major Theme	Subthemes
Technology integration	Best Practices
	Teacher's skill of using technology
	Acceptability and attitudes toward
	synchronous corrective feedback
Platform Interactions	Student motivation and confidence
	Impact on cognition
	Contribution to learning process (platform data)
	High to moderate interactions
Institutional Support	Time limitation
	Lack of institutional supported professional development

Technology Integration

The high school teachers provided great insight into their implementation and integration process. When speaking about the implementation process, Mike gave an obvious process for his implementation. Mike stated:

> So, the first step to using those platforms for me as a teacher is I need to know what it looks like. And so, if I can get some sort of demo, or some sort of process of just kind of exploring it for myself, I really need to know as a teacher, what's inside of that, and where it's going to be bringing students.

Mike's insight was indicative of several of the teachers as they implement online learning platforms. James' approach to implementation:

> When you say implementation, I kick it off right away. I show the students that resource in the very first session with students. I tell them that we will utilize this tool, and it's going to help identify where your weaknesses are so I can help you.

Additionally, Ray's approach to implementation to specific platform was informative by stating his use of Desmos:

> So mainly, for Desmos, I use it when I need to explain something to students going from a textbook too, in a way, like a visualization tool. So, when I'm introducing skills or doing things that it's a word problem, I definitely put on Desmos if I need to or help students visualize.

Best Practices

Innovative use of online platforms was noted throughout all three sites. Every teacher demonstrated an understanding and usage of multiple platforms that support their student's learning. In the interview and classroom observation, Mary specifically noted the innovative approach of gathering multiple data points from several platforms. She spoke in detail about the use of Google Forms and providing students with real-time corrective feedback through videos attached to students' responses. Mary stated:

> I used a Google Form to get responses because when you insert your answer, you can also insert or attach a video, like a teaching video, or attach the resources. So, when the student gets the answer-back, they can also see the video, which, if I'm not there, they can get more of an explanation of how you get your answer, so they can see the video of how to get the correct answer. I like that because it releases me a lot, and I'm not having to approach every single student.

Brandon highlighted best practices when he discussed how often he requires technology usage within his course:

> So, we have specific standards for using technology to graph or model data. And we have one specific standard: I use Google Sheets to model scatterplots and fitting exponential curves. So, I am flexible with them taking notes on the iPad because the math class is not something you can type. So, iPads, Microsoft Surface, anything with a writing tool; I have students who do their homework on their tablets so that they use their tablets throughout the class, and I'm okay with that.

All of the participants used Google applications. The application description varied from the site, but I noted the commonality throughout the study. Mike described his requirements of asking students to check solutions to homework after he published the documents in a Google Drive folder. Mike stated, "Each student uses their computer to check those work solutions." Mike also highlighted the importance of immediate feedback and why he places the documents within the Google Drive folder for his course, "The students have access to the solutions immediately, whenever they need it. They know that they can go back and look at it."

Technology Knowledge

The understanding of technology varied at each site. Some teachers promoted their ability to quickly understand technology, while others were apprehensive about using multiple platforms. Mike said:

> I am a tech guy. I look at tech news for fun; I investigate all kinds of things on my own. And so, I kind of laugh a little bit when somebody sends me very detailed instructions about, oh, you need to click here, and they need to click here. I was just like, okay, I mean, it seems obvious to me, but I don't think that's the norm."

Brandon had the same insight as Mike by stating, "I was the tech coach for 12 years, Desmos, I think is fairly straightforward." On the contrary, James stated, "I'm a rookie in education and rely heavily on others to help me with technology."

Attitudes Towards SCF

The mathematics teacher's attitudes varied with the perceptions of SCF. Most teachers agreed that computer-mediated information to support student learning is beneficial. Tom asserted:

> I decided to use IXL and the reason why is because I can watch all the students in real-time. I can see which ones they are missing because IXL gives them immediate feedback. That was quite rewarding for me to see how engaged they were by using that platform and for me to have the real-time assessment of their abilities.

Sam uses platforms that provide SCF; however, he offered helpful insight into a perspective that considered the time a student uses the resources that he was unaware of when he assigned the learning tasks. Sam told the story of a student that used the platform for hours to work through assigned tasks but did not fully complete the assignment with the appropriate score. Sam utilizes technology but insists that there are times when one-on-one learning is best for the learner. Sam explained:

> I was like, Oh, my goodness, you spent how long on this? And then I talked to her, and we sat down one-on-one, and I could help her more than the computer program. And then she was good. I think it was the next day after I saw how long she spent on IXL that I was shocked.

In contrast to most teachers, Sally felt that traditional feedback was better suited to her students than SCF using technology. She stated:

> I like the traditional way of how teachers give feedback, like, individually, I go around the room and really check on how they are going through each of the solutions, what their style is, because, you know, each kid could work on several different ways on how they present their work. And so yeah, I go around the room, and I allow them to also consult with each other, so they do peer work. I don't know if a computer would give feedback as I think my students need it.

Platform Interactions

The high school mathematics teachers varied in their interactions with the online mathematic platforms. The participants' range of interactions with the platforms varied, and the platforms used within the similar courses varied depending on the teacher and site. Six of the nine participants utilized IXL, seven interacted with Desmos, three promoted GeoGebra, and all participants used the Google Suite applications within their mathematics courses. Additionally, all participants used a platform that provides SCF for homework. James provided an example of his interaction with IXL:

> Because of IXL's diagnostic capabilities, I can immediately go to, for example, a grade-level seven that has integers and operation problems. So, it's easier to identify the skills that the students actually need. So, it's easier for them to improve with a focused program.

There were a variety of features on each platform that the teachers utilized. Tom asserted, "I decided to use IXL, and the reason why is because I can watch all the students in real-time." Mary explained the use of Demos. She stated:

> And that's why in math for my class, they have to show the work when using Desmos; that's how I know where they make a mistake. However, I think online platforms can give them feedback immediately, like, whether the answer is correct or not, and that is the most beneficial for the students.

High to Moderate Interactions

I noted that the teachers had high to moderate use of the synchronous platforms. High use teachers utilized the platforms daily, while others only used the platform if extension work was needed throughout the mathematics units. However, I was able to note through the interviews, classroom observations, and focus groups that the level of interaction depended on each teacher's implementation process. The teachers that utilized the platforms regularly used the student learning data to support lesson planning and formative data. Tom, who uses IXL in his classroom daily, stated, “Practicing with the online platform, I realized that this is actually a very effective way for me to be able to reach all my students." Ray described his interactions with the platforms by stating:

> I do let them do IXL as practice for homework. In addition, if I feel the kids need immediate feedback for this assignment, I just give them IXL Math, and then they can work through it. And then, they can self-check it, which is helpful for my students.

Furthermore, Mike was specific about interactions with platforms by asserting:

> The online platforms that can provide instantaneous feedback can be very useful. I admit, the software I used, Kuta software, gave me a little bit more flexibility on the types of questions I could ask, and then they have corrective feedback instantaneously. The drawback is that oftentimes platforms, you need to ask their questions or their questions are already preset like I think of Khan Academy, where the teacher has no control over the questions that will be asked. And the students figure out that the questions repeat enough that they can just cycle through the questions long enough until they get to the repeating questions.

Impact on Cognition

Six of the nine participants noted the impact on cognition asserted within the repetitive nature of the platforms. James elucidated:

> My students remember the concepts because I give them time to work with IXL problems. We work the problems together, and they also work the problems on paper, so we can find out if it's computational mistakes or misconceptions with their understanding of the concepts.

Tom reviewed IXL and noted that while it assists students with learning, it cannot wholly understand simple errors students often make in computational calculations. Tom's explanation:

> The students' answers must be very precise. And so, they're, if they're off by just a tenth, then IXL doesn't notice that, oh, you almost got it, right. So clearly, you know, give them some grace. So IXL doesn't do that; it's either right or wrong. And so, a lot of the time it comes up wrong, and I'll go over, and I say, ah, I see what you did, and you knew you knew exactly what to do, you have mastered the skill, your problem lies in your computation.

Brandon referred to his student's perceptions and frustrations that limited learning. Brandon explained:

> I know students complain about doing something like Khan Academy and getting stuck on getting five questions correct. It is a cycle. So, I just log in as a student and then try the questions until I get a feel of what it feels like. So, there is not any specific training, I think. I think just using a little bit of empathy and then putting yourself in a student's shoes and trying a lesson; if I get them wrong, what happens? You realize that this is very frustrating and adjust your expectations.

Impact on Motivation and Confidence

Most teachers agreed that the impact on motivation and confidence amongst students was apparent when the students were using the platforms. Tom offered an explanation when explaining IXL:

> The first five questions on any section are pretty simple; they just teach the routine. But then the latter four or five questions really get into the meat of the problem to see if they really know what to do when they're faced with questions that aren't obvious, right up front. So, we have to go at least that far, and because of that, if they make a mistake, points are deducted, and percentages are deducted. And so that can be very frustrating for

> the student. So, if I sense the student is frustrated, I'll go to the student, and we may change focus for a while. So, for some students, it can be very frustrating. But at the same time, I tell them, this is very valuable for you. Because we get the higher-level math, your precision is really important. So, you need not just know how to do it. But you've got to actually nail it. You've got to get it exactly right.

Brandon asserted a similar response, "Once a student decides that the platform is not for them, it might be really hard to change that mindset. So definitely from my experience with IXL, knowing how communicating the expectation to a student makes such a big difference."

Satisfaction with Platform Data

The platform's data provided to the teachers was valuable, and most teachers agreed that it supported student learning. Sam provided an example of the IXL's SmartScores:

> The thing that's nice about IXL's SmartScore is you can actually see the score by a question, what the students are doing wrong. I would use the score if they had spent a lot of time and the score didn't reflect a solid enough understanding, then I go in and see what they're missing and ask myself if it's computational errors or they don't understand it at all. It's very useful data.

Tom used the data from IXL to support student learning. He provided a response that explained the need for real-time data by stating:

> The problem I faced was that I needed to follow the students in real-time with what they were doing. I need to know when they reach a certain percentage of questions answered correctly. I knew this; IXL must be able to do that, because I can see it on the platform. You know, I can look at their side and see what percentage the students are at. This has

> helped me as a teacher because I can see where my students are in the learning process, especially when teaching new concepts.

To provide additional support to students, Ray explained how data from the platform is used. Ray stated:

> For homework, I ask them to give me a corrected version of their work on Delta Math, for example. Still, some students do not complete their homework tasks, or if they get too many wrong, I just give them the assignment back and say I want you to redo it. And then, if needed, they can come during 3R for my help, and I can walk them through a couple of these questions. And then, I ask them to submit the assignment again. This information from Delta Math has helped me provide more help to my students.

James explained the use of diagnostic baseline data that IXL provided him. Based on the data points, he could identify each student's specific areas of concern. James asserted, "IXL also has a diagnostic capability. So once in a while, I ask the student to go in there just to do all sorts of questions, which helps me see their weakness."

Institutional Support

The mathematics teachers from all three sites provided a succinct articulation of the institutional support that the schools provided. Several participants stated that the institution provided fantastic resources for their courses, but the professional development and time allotted for peer collaboration were limited. Most of the participants felt that because of Covid-19 and their need to teach their courses online, they were rushed into using the resources. Tom noted, “I just figured it out as I went through the course because I didn’t have an option. My students needed help, and IXL was there, so I had to use it.” When speaking about her support, Sally provided insight:

> So, two years back when we were asked to go online, there were a lot of teachers that were helpful; they were like, just suddenly giving us links and telling us to see if it relates to our course. I benefited from colleagues by just really out of the blue having a list of links that you can play around with go to and check if it's applicable for classwork.

Mary explained how she and her department members collaborate. This provided opportunities for her to learn about online resources. Mary explained, "When I have time, I just talk to people who are also teaching the same content and hear how other people are using various technology or how I can use various tools that also gives me ideas."

Institutional Supported Professional Development

Every participant shared that their site did not provide any specific opportunities to learn how to use the online platforms. Charlotte stated, "I can't think of any recent professional development sessions I've been to that specifically helped me in this area." Brandon asserted, "So there's not really any specific training for Desmos; I just had to figure it out on my own." Ray explained:

> I have been to ACSI conferences. I mean, one thing about the conferences is that I get to talk with other teachers in the same field; I joined the math group and saw what they had to offer and stuff. I actually explored it myself, and then I've talked to colleagues here. I borrowed ideas from other teachers from other subjects and stuff. So, I try to get a different feel for different ways of what people are doing. And I have my system going on, but I borrow ideas to ensure kids are not learning something completely new.

Time Limitations

All participants expressed the challenges of finding time to plan and provide professional development and peer collaboration. Additionally, within the focus group interview, each participant agreed that peer collaboration is what best supports their professional growth, but no time is given for effective collaboration within school hours. Charlotte admitted to appreciating professional development but not engaging in it during outside work hours because:

> As a teacher, who also has a life outside of school, it's just been really challenging to want to commit that time to go to a math retreat or go-to professional learning weekends that takes up two days of your spring break. Right now, I have no motivation to sacrifice more time in doing that.

Additionally, James noted the lack of time by stating, "So, all this I learned not here at Morrison. I do not know if there would be any time to take on professional learning in my day." According to Sam, “Initially, the site provided professional learning, but in recent years there has been a lack of time for specific mathematic resources.” Sam stated:

> At Morrison, you know, we just started last year with IXL. A few years ago, we had some people come in for training. But I don't think it was for IXL; there's a No Red Ink person. But now for these things, it is kind of just what I can find on YouTube, their websites, and stuff like that.

Research Question Responses

The following section provides the findings to the central research question and two sub-questions. These questions were designed to obtain information and provide detailed descriptions of the participant's implementation and use of online platforms that provide real-time corrective feedback. Much literature has been presented on the implementation and usage of online SCF in English Language Arts classes; however, a limited amount of research is presented on the implementation and usage of online SCF in high school mathematics classes (Gaona et al., 2018; Kang & Han, 2015). The following responses were synthesized from the themes and sub-themes identified in the analysis of data collected. The participant's responses to the interview questions, focus groups, and the researcher's observations develop the themes that appeared in this study. Below are the questions and findings from the participants.

Central Research Question

The central research question was: How do high school mathematics teachers implement and use online learning platforms that provide real-time corrective feedback? The central question was designed to understand the implementation and usage of online learning platforms that provide SCF from the high school mathematics teachers. Multiple synchronous platforms were used during this study, and the participants provided insight into the implementation process. The platforms mentioned repetitively during the interviews and focus groups were Desmos, IXL, GeoGebra, and Google Suite Applications. Three themes emerged from the study. The first theme highlighted the implementation and integration process.

When sharing their experiences with implementing and using the platforms, recurring patterns occurred in many of the participant's responses; however, a variety of answers were provided. Before implementing the selected platform, long periods of planning take place and each participant previewed the platform before assigning the work to the student. Mike explained:

> I think Desmos does a pretty good job at letting you preview the materials, and, of course, GeoGebra, you can kind of look through. IXL is a little bit more difficult because you kind of have to go in, and you have to kind of jump to levels to see like, what is this assignment going to look like.

James' approach to implementation:

> When you say implementation, I kick it off right away. I show the students that resource in the very first session with students. I tell them that we will utilize this tool, and it's going to help identify where your weaknesses are so I can help you.

Brandon's explanation provided a perspective that encompasses the skills for integration, attitude toward SCF, and implementation into his course:

> IXL, I think I mentioned a little bit already; I would set them up with their account, and I will assign them activities, but I actually want them to do the activities not in alphabetical order, but in the order of my standards. So then, I set up a Google sheet that I have with all the checkmarks with a standard and the lesson they're supposed to do; I then use import range to create an individual spreadsheet that pulls data from my master sheet so that students don't see any other student's progress. And they will refer to that and then just go to the next assignment. And most students would just come in, click on the link they were working on last time, and kind of get to work. And then, since they're only doing it during class time when they're done, they would just raise your hand. I'm the one at the back of the room with the spreadsheet open tracking their progress.

Sub-Question One

The first sub-question was: How do high school mathematical educators describe their interactions with synchronous platforms that provide real-time corrective feedback? The participants ranged from high to moderate interactions with the platforms. The interactions depended on the participant's site and correlating factors contributing to the usage. Not all participants used the platforms daily; some used the platforms for homework review, the introduction of concepts, and skill practice. During James' focus group interview, he said:

> Another thing would be with IXL; it's easier to differentiate within one class, particularly with a large class where we have the range is pretty wide. So, let's say for those who are more advanced in math, I can assign them a different level of question. Last year, there was one kid who was able to do Algebra One level of math in grade six, so rather than, you know, keeping her waiting for the others, I can assign her questions at her level. To me, that would be a success story with using IXL, so students are more engaged they don't feel as bored, especially for those who are more advanced in math. I have access to those types of questions from IXL.

The observations and interviews indicated high to moderate use of the platforms. Tom acknowledged the opportunity to follow students in real-time, which is why he used a particular platform. Tom stated, "I decided to use IXL, and the reason why is because I can watch all the students in real-time." Multiple participants on each site used Desmos. Mary explained the use of Demos. She stated:

> And that's why in math for my class, they have to show the work when using Desmos; that's how I know where they make a mistake. However, I think online platforms can give them feedback immediately, like, whether the answer is correct or not, and that is the most beneficial for the students.

Sub-Question Two

The second sub-question was: How do mathematics teachers perceive the support level of synchronous, online corrective feedback in high school mathematics courses? The participants from each site stated that the institution provided resources that were beneficial for them and their students, but no professional development was given and that time constraints to learn and implement new platforms inhibited the full use of the platforms. During Charlotte’s focus group interview, she stated:

> The benefits would be that the feedback is almost immediate. It is also visual for the students; I find that one of the disadvantages that come up often is that I first have to spend time exploring the platform first. And that is sometimes very time-consuming. For example, lots of math teachers have been telling me about Ten Marks and Extra Math. And I feel like I always need to create a dummy class to experiment with first in order to figure out how I will actually implement this.

Sam's interview encapsulated the lack of platform support that all participants expressed by stating:

> Honestly, with IXL, I am just kind of self-taught. I went on the website, and kind of just like, tried to figure things out myself, because at the time, like their trainings were kind of weird, and I didn't want to spend time with the training.

Additionally, Brandon asserted, "So there's not really any specific training for Desmos; I just had to figure it out on my own."

Summary

This study aimed to present an in-depth understanding of teachers implementing and using online synchronous technology that provides real-time corrective feedback for students in a high school mathematics course located at three international high schools in Taiwan. In Chapter Four, a description of the participants was given, and the themes were presented. After interviewing all participants, conducting observations, and hosting focus group interviews, each case's data was analyzed independently using Stake's (2006) strategy using worksheets. After I determined the themes for each case, the cross-case analysis began.

The themes that emerged from the data include technology integration, platform interactions, and institutional support. The subtheme for innovation includes best practices, teacher's skill of using technology, and acceptability and attitudes toward SCF. The subthemes for platform interactions includes student motivation and confidence, impact on cognition, contribution to learning process, high to moderate interactions. Finally, the subthemes for institutional support consisted of time limitations and lack of institutional supported professional development.

The central research question was, "How do high school mathematics teachers implement and use online learning platforms that provide real-time corrective feedback?" The assertions that emerged is that implementation was always proceeded by long periods of planning and previewing materials before the platforms are introduced to students, and the data that is acquired from the platforms is used to support student learning.

CHAPTER FIVE: CONCLUSION

Overview

This case study aimed to provide an in-depth understanding of teacher's experiences implementing and using online synchronous technology that provides real-time corrective feedback for students in a high school mathematics course located at three international high schools in Taiwan. The chapter consists of five discussion subsections: (a) interpretation of findings, (b) implications for policy and practice, (c) theoretical and methodological implications, (d) limitations and delimitations, and (e) recommendations for future research.

Discussion

The following section addresses the empirical data illuminated from the findings in the context of the theoretical framework proposed in the Chapter Two literature review. The theoretical literature incorporated Bloom's (1968) mastery learning and Piaget's (1972) cognitive learning theories (Guskey, 2007). The mastery learning theory and cognitive learning theory informed this study because the components of each theory should be present within the learning environments as teachers implement and use technology that provides SCF. Spyropoulou et al. (2013) posited that creating learning environments that encourage students to connect with previously learned material is an instructional design that promotes cognitivism.

Interpretation of Findings

The findings are interpreted based on the empirical findings from high school mathematics teachers who participated in this study. I gathered data by conducting individual interviews, focus groups, and classroom observations. Classroom observations were completed after the individual interviews so that the researcher could determine the credibility of the individual interview data. The interpretations are also based on the decades of educational experience that the researcher provides, and the literature review completed prior to gathering data.

The study took place at one school system in Taiwan. The school is one system but comprises three campuses that started in 1952 to meet the educational needs of children of missionaries. Additionally, the school welcomes children of other expatriates. The cases for this collective case study were the three schools within the system, and the teachers were the embedded units of analysis.

Summary of Thematic Findings

A summary of Chapter 4's interpretations and themes are provided here. The data collection process consisted of individual interviews, classroom observations, and focus groups. Technology integration and how teachers integrate the platforms used to provide SCF were at the forefront of the findings. The second theme that emerged was how teachers and students interact with the platforms that were used in the high school mathematics classes. The final theme that emerged was the level of institutional support that was provided to the teachers.

Technology Integration and Usage

New technology and educational advancements are rapidly increasing and at the forefront of education (Carrington, 2020; Crawford, 2016; Toothaker & Taliaferro, 2017). The new technologies have contributed to developed resources for educators and students (Carrington, 2020; Kawada, 2018; Schuetz et al., 2018). When sharing their experiences with implementing and using the platforms, recurring patterns occurred in many of the participants' responses, and various answers were provided. However, all participants agreed that before implementing the selected platform, long planning periods take place, and the platform must be previewed before assigning the work to the student. Mike offered:

> So, the first step to using those platforms for me as a teacher is I need to know what it looks like. And so, if I can get some sort of demo, or some sort of process of just kind of exploring it for myself, I really need to know as a teacher, what's inside of that, and where it's going to be bringing students.

Additionally, all teachers agreed that integrating technology that provides SCF into classroom learning environments is considered part of best practices for student learning by giving students individual practice that supports mastery of the content taught. Researchers contend that providing correctives within the formative evaluation process will support overall student learning (Amiruddin et al., 2015; Bacquet, 2020; Brookhart et al., 2016; Connors, 2021; Guskey, 2015; Schimmer et al., 2018). All of the participants for this study expressed that using some type of technology to support their mathematics courses is essential, especially those that provided data by identifying deficit skills that illuminate academic gaps. James stated, "IXL also has a diagnostic capability. So once in a while, I ask the student to go in there just to do all sorts of questions, which helps me see their weakness."

Using technology to enhance student learning is essential to enhance student learning (Crawford, 2016). However, the implementation procedures of the online resources varied from each participant and school. A large percentage of the teachers expressed that they implement a specific resource without prior knowledge of the platform, and most teachers are using a platform based on a recommendation from a colleague. The teachers consistently stated that the first interactions with the technology are self-taught with minimal support. Appropriate professional development and support should be identified and implemented (Crawford, 2016; Toothaker & Taliaferro, 2017). Crawford (2016) posited that educators should use the implementation and application of the technology with effective professional development (Crawford, 2016).

Platform Interactions

The participants ranged from high to moderate interactions with the platforms; however, the teachers from each school agreed that using the platforms that provide SCF to identify learning gaps as data exposed deficit skills was very useful for their classes. The collaboration and immediate learning of concepts is fostered within the online resources (Beldarrain, 2007; Kutaka-Kennedy, 2015; Martin et al., 2017).

The teachers agreed that technology is a great tool to individualize the practice for mastery and to gain exposure to new content. Lavolette et al. (2015) stated that the effectiveness of synchronous feedback through technology is immediate and beneficial for students rather than delayed feedback. Mary's response explained benefits of using resources that provide real-time corrective feedback:

> I used a Google Form to get responses because when you insert your answer, you can also insert or attach a video, like a teaching video, or attach the resources. So, when the student gets the answer-back, they can also see the video, which, if I'm not there, they can get more of an explanation of how you get your answer, so they can see the video of how to get the correct answer.

Providing students with skill level opportunities to respond to appropriate and efficient learning can provide effective learning opportunities for both the teacher and student (Palocsay & Stevens, 2008).

Additionally, the teachers expressed concerns with the technology that provides immediate feedback as a challenge for mathematics classes because artificial intelligence cannot differentiate between computational errors or lack of conceptual understanding. The teachers agreed that students become discouraged and motivation decreases because the platforms are unable to differentiate between the levels of understanding while following Bloom's (1968) mastery framework (Guskey, 2015). Brandon said:

> I know students complain about doing something like Khan Academy and getting stuck on getting five questions correct. It is a cycle. Once a student decides that the platform is not for them, it might be really hard to change that mindset.

Tom's response indicated similarly to Brandon when referring to IXL's interactions, "Because we get the higher-level math, your precision is really important. So, you need not just know how to do it. But you've got to actually nail it. You've got to get it exactly right." Motivating student learning has long been problematic for educators and students (Clark, 2018). However, as motivation increases for a student, so will the level of mastery because the learner is pursuing the content because of appropriate cognitive skills (Clark, 2018; Semerci & Batdi, 2015).

Institutional Support

Providing and maintaining institutional support emerged as a significant theme emphasized by the participants. The participants from each site stated that the institution provided resources that were beneficial for them and their students, but no professional development was given and that time constraints to learn and implement new platforms inhibited the full use of the platforms. While new technologies and resources are easily accessible, educators should use the implementation and application of the technology with effective professional development (Crawford, 2016). Sally stated, "I benefited from colleagues by just really out of the blue having a list of links that you can play around with go to and check if it's applicable for classwork." To become competent in utilizing resources, some teachers proposed continuous professional development for themselves. Brandon said, "So there's not really any specific training for Desmos; I just had to figure it out on my own." Focusing on professional learning that develops the usage of new technology provided researchers with an understanding of how support the mathematics classroom (Bacquet, 2019; Park, 2021; Pierce & Ball, 2009; Thomas, 2006). Additionally, all participants agreed that providing time within the working hours to collaborate with colleagues would be more beneficial than systematic professional development. Charlotte said:

> As a teacher, who also has a life outside of school, it's just been really challenging to want to commit that time to go to a math retreat or go-to professional learning weekends that takes up two days of your spring break. Right now, I have no motivation to sacrifice more time in doing that.

Implications for Policy or Practice

This case study aimed to provide an in-depth understanding of teachers' experiences implementing and using online synchronous technology that provided real-time corrective feedback for students in a high school mathematics course located at three international high schools in one school system in Taiwan. Previous studies in the literature emphasized the use of synchronous technology that provided real-time corrective feedback in English Language Arts or English Language Learning courses as beneficial to student learning; however, an apparent gap within the literature was acknowledged with consideration to high school mathematics courses (Gaona et al., 2018; Kang & Han, 2015). Addressing this gap in the literature adds to the body of knowledge concerning the experiences of how teachers implement and use online synchronous technology that provides real-time corrective feedback. This qualitative study explored how teachers implemented and used SCF platforms within their high school mathematics courses. The results of this study add to the existing studies discussed in Chapter Two.

Implications for Policy

Technology for education has been heavily invested in, according to George and Sanders (2017). According to George & Sanders, integrating technology into school will improve teaching and learning (George & Sanders, 2017). Digital learning and the adoption of educational technologies have been driven by the belief that technology can transform teaching and learning (George & Sanders, 2017). Therefore, it would be helpful for policymakers to consider the input of educators when developing school calendars that include systematic professional development. School leaders could benefit from listening to teachers by incorporating time for professional development into school calendars. Teachers are not investing personal time into learning new resources; therefore, the policymakers should seek to ensure that educators are trained and equipped to implement educational resources that will allow them time to collaborate with colleagues and explore the resources that are being used within the learning environment during school hours. Charlotte said, “As a teacher, who also has a life outside of school, it's just been really challenging to want to commit that time to go to a math retreat or go-to professional learning weekends that takes up two days of your spring break.” Teacher collaboration should be encouraged and supported by the policies that are made.

According to this study, the participants relied heavily on the collaboration from colleagues. By incorporating time into schedules for peer-collaboration policy makers could see the benefits of this strategy as new resources are implemented into the mathematics classroom. Additionally, offering data that exhibits positive student learning outcomes while using the platforms would be valuable. This provides the educators with examples of how the platforms are benefiting student learning, motivation, and retention. By implementing common planning time, professional learning communities, and voluntary peer groups with time, teachers will may develop authentic learning environments that address the beneficial endeavors and advance their skills and dispositions relating to student learning.

Implications for Practice

It is imperative that teachers are well prepared to work with educational technologies if we are to improve online learning and teaching (Bacquet, 2019; Burgers et al., 2015; Dahal, 2016; Fyfe et al., 2017; Hadiyanto, 2019; Jovanović, 2019; Kang & Han, 2015). Based on the current study's findings, teachers need support in creating meaningful interactions and incorporating digital content into classrooms to engage students more effectively. According to George and Sanders (2017), the most successful professional development strategies are based on teacher needs, identifying the needs of teachers, and developing professional development based on those needs. To integrate technology into educational activities, teachers may need help because many do not possess the skills or knowledge to design effective online activities (Carrington, 2020). New teaching strategies are influenced by teachers' perceptions, beliefs, and skill levels (Carrington, 2020).

There are multiple forms of correctives that may be used for a learner that provide formal and informal through formative and summative interactions. According to Sato and Loewen (2018), the most common forms of corrective feedback that are used with students are oral feedback, written corrective feedback, and technology-mediated feedback. Policymakers and educators may come to utilize resource materials that synthesize the understanding of how people learn so that adequate and immediate feedback could be effective for students. Additionally, teachers could join other research teams that are developing artificial intelligence that can help students learn better and faster when paired with high-quality learning materials and instruction. Teachers could pilot the artificial intelligence systems in the high school mathematics classrooms.

Theoretical and Empirical Implications

The theoretical and empirical implications between the findings of this research are discussed below.

Theoretical Implications

The participants of this study believed that providing immediate feedback to the mathematics students is significant to the learning process, and implementing and using platforms that provide immediate feedback is effective for twenty-first-century learning environments and cognition. As educators use technology to create collaborative environments, technology integration must be done properly. Piaget's (1972) cognitive learning theory is based on creating long-term memory of information received in stages (Pandey, 2018; Sternberg et al., 2016). Bloom's (1968) mastery learning theory suggests that with correct instruction and time to learn the material, all students can achieve the desired objectives at satisfactory levels (Guskey, 2007; Hussain & Suleman, 2016). Spyropoulou et al. (2013) posited that creating learning environments that encourage students to connect with previously learned material is an instructional design that promotes cognitivism. Therefore, using synchronous technology may support the learner as they develop the knowledge of the content as indicated within this study.

The case study sheds light on using cognitive-based technology that provides instructional explanations and demonstrations as the learners use the platforms. According to Bloom's (1968) mastery learning theory, the role of the educator in the development of cognition is emphasized through the corrective feedback is essential for student learning (Guskey, 2015).

Within Bloom's (1968) mastery learning framework, feedback is essential to student learning, thus providing the learner support to learn the selected material (Guskey & Gates, 1986; Guskey, 2007, 2015). Technological platforms used within the study enhanced student learning and teacher support, as described by the participants making Bloom's (1968) and Piaget's (1972) theories appropriate for studying the implementation and usage of online synchronous platforms that provide real-time correct feedback.

Empirical Implications

There has been a plethora of literature describing the use of online platforms that provide corrective feedback (Carrington, 2020; Lee, 2011; Sahin et al., 2002; Wang, 2014). In addition, literature can be found describing the implementation and use of online platforms that provide SCF in ELA or ELL classes through the use of Grammarly or other online programs (Gaona et al., 2018; Lavolette et al., 2015; Sweigart et al., 2015); however, there is a limited amount of literature representing a gap in the literature on the implementation and use of online platforms within the high school mathematics courses (Gaona et al., 2018; Kang & Han, 2015). Therefore, this study provided information from teachers who are implementing and using technology in their mathematics courses. The participants provided information about how they implement and use the technology giving the teachers a voice about their lived experiences and perceptions of implementation and usage. The participants expressed their intentional attempts to use resources but also raised concerns that they had little to no time to collaborate with other educators to enhance the use of platforms. They also provided information about how they use the data that is provided by the platforms to support their learners and raised concerns about the type of feedback that the platforms are able to give the learners. Thus, providing insight for further research.

Limitations and Delimitations

The study's limitations included the lack of previous research studies within high school mathematics courses. While multiple studies explain the use of synchronous technology within English Language Arts and English Language Learning courses, there was a lack of previous research studies focused on high school mathematics. Additionally, the study has a small sample size because some of the participants withdrew from the study. Issues with the research sample and selection were part of the limitations of this study, and this limited the opportunity for observations and interviews with more participants at each site. Therefore, the qualitative findings were based on small samples and teachers from different learning environments.

Due to the COVID-19 pandemic, the research was conducted in three schools in one school system in Taiwan and was not expanded to include other schools in Asia. Finally, my research was conducted at a disadvantageous time of year. Because the research was conducted during the second semester of a school year, data were gathered near the end of the school year, and teachers were concerned with finals, grading, and time constraints.

To join this study, the participants had to be certified teachers and teach a high school mathematics course at one of the three sites in Taiwan. Delimitations included using only certified teachers who are teaching high school math courses and teaching at one of the three locations. The researcher explicitly focused on high school courses because the study sought to provide the perspective of implementation within higher-level mathematics courses. Also, the study focused within one country; therefore, the expectations of mathematics in a course may be different from other countries. These delimitations might affect the replication of research in other areas. A larger sample population, research site, and region could improve the generalizability of this study.

Recommendations for Future Research

Future research should be conducted on how teachers implement and use online platforms that provide SCF. Additionally, it would be beneficial to study the student learning results as the teacher implements or how the teacher chooses to implement such technology. Conducting student interviews may allow researchers to gather rich data on this topic from the student's point of view by using these platforms to support learning.

This study primarily focused on implementing and using online platforms that provided SCF. However, I would recommend that studies be conducted on the development that uses artificial intelligence to continue developing platforms that distinguish between types of feedback necessary for each student. The research opportunity is expansive in both scope and duration; however, it could be coordinated between schools that cooperatively pursue this endeavor.

Conclusion

This study explored the implementation and usage of online platforms within high school mathematics classes at schools located in Taiwan. Participants included nine teachers, three females and six males, that teach at one of the three school campuses. Data were collected through interviews, classroom observations, and focus groups. The findings indicated that teachers are using a variety of platforms that provide SCF in their classes, but the implementation of the resources varied.

The themes that emerged from the study included implementation and usage, platform interactions, and institutional support. The participants shared information about how they use the data that is gathered as students use the platforms. Most of the participants agreed that using the data that is presented immediately provides information so that planning and learning can be enhanced and supported. The participants shared that providing students with immediate feedback is necessary, but platforms that differentiate the type of feedback are not yet created. This provided the researcher with information for suggested additional research opportunities. Overall, it can be concluded that using online platforms that provide SCF benefits teachers and students.

The rapid development of technology will allow high school mathematics educators to provide students with real-time feedback through the use of this study. Many benefits are present by implementing and using technology in the classroom, although the development of artificial intelligence that is not finished supports differentiation of the type of responses the students are giving; however, further developments and studies will support this endeavor. Hopefully, these resources will support the twenty-first-century learner in high school mathematics.

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Appendix A

Appendix A: School Recruitment Letter

To: [School Superintendent]
From: Sharon B. Owens: Doctoral candidate at Liberty University
Subject: Research Permission Request

Body: Dear School Superintendent:

As a graduate student in the School of Education at Liberty University I am conducting research as part of the requirements for a Doctor of Philosophy (Ph.D.) degree. The purpose of my research is to examine the implementation process of synchronous technology and corrective feedback in high school mathematics courses, and I am writing to invite Morrison Academy to join my study.

Participants must be high school mathematics teachers. Participants, if willing, will be asked to conduct two interview sessions, allow for a classroom observation and complete a questionnaire. It should take approximately two weeks to complete the procedures listed. The participants will be completely anonymous, and no personal, identifying information will be collected, furthermore, information that is gathered will remain confidential and will be destroyed.

Thank you for your consideration.

Sincerely,
Sharon B. Owens
Email: [redacted]

Appendix B

Appendix B: School Recruitment E-mail

To: [School Superintendent]
From: Sharon B. Owens: Doctoral candidate at Liberty University
Subject: The purpose of this study is to examine the implementation of synchronous technology and corrective feedback in high school mathematics courses

Body: Dear Principal:

As a graduate student in the School of Education at Liberty University I am conducting research as part of the requirements for a Doctor of Philosophy (Ph.D.) degree. The purpose of my research is to examine synchronous technology and corrective feedback in high school mathematics courses, and I am writing to invite Morrison Academy to join my study.

Participants must be high school mathematics teachers. Participants, if willing, will be asked to conduct two interview sessions and allow classroom observations. It should take approximately two-weeks to complete the procedures listed. The participants will be completely anonymous, and no personal, identifying information will be collected, furthermore, information that is gathered will remain confidential and will be destroyed.

Thank you for your consideration.

Sincerely,
Sharon B. Owens
Email: [redacted]

Appendix C

Appendix C: IRB Approval Form

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

February 17, 2022

Sharon Owens
Wesley Scott

Re: IRB Exemption - IRB-FY21-22-448 EXAMINING SYNCHRONOUS TECHNOLOGY AND CORRECTIVE FEEDBACK IN HIGH SCHOOL MATHEMATICS COURSES: COLLECTIVE CASE STUDY

Dear Sharon Owens, Wesley Scott,

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 D

Appendix D: Recruitment Email

To: [Potential Candidate]
From: Sharon B. Owens: Doctoral candidate at Liberty University
Subject: The purpose of this study is to examine synchronous technology and corrective feedback in high school mathematics courses

Body: Dear High School Mathematics Teacher:

As a graduate student in the School of Education at Liberty University I am conducting research as part of the requirements for a Doctor of Philosophy (Ph.D.) degree. The purpose of my qualitative collective case study research is to examine synchronous technology and corrective feedback in high school mathematics courses, and I am writing to invite you to join my study.

To participate, please click here (Research Survey).

The participants must be high school mathematics teachers. Participants, if willing, will be asked to participate in two interview sessions and allow classroom observations. The interview sessions will take approximately 30 to 40 minutes. The first interview will be individual interview and the second will be with a group of participating teachers. It should take approximately two-weeks to complete the procedures listed. The participants will be completely anonymous, and all information that is collected will remain confidential and will be destroyed. Your name and/or other identifying information will be requested as part of your participation through an online questionnaire, but the information will remain confidential. Additionally, once the interviews have been transcribed, you will be given a full transcript to review.

For more information please do not hesitate to contact me.

Sincerely,
Sharon B. Owens
Email: [redacted]

Appendix E

Appendix E: Screening Survey

Note to reader: The actual Google Form questionnaire is produced and delivered to the recipient in digital format via e-mail and features interactive check-boxes and expanding blank spaces for written answers.

1. Do you currently teach a high school mathematics course?
    a. Yes
    b. No

2. Do you hold a teaching certification from a state or recognized accredited agency?
    a. Yes
    b. No

3. Have you used any of the following technology platforms in your courses? (Select all that apply).
    a. Desmos
    b. Khan Academy
    c. Google Docs
    d. Udemy
    e. Coursera
    f. Elluminate
    g. Blackboard Collaborator
    h. Udacity
    i. Skillshare
    j. Other (please specify the platform below)

4. Please select the school that you currently teach at.
    a. Morrison Academy Taipei
    b. Morrison Academy Taichung
    c. Morrison Academy Kaohsiung

Appendix F

Appendix E: Participant Consent Form

EXAMINING SYNCHRONOUS TECHNOLOGY AND CORRECTIVE FEEDBACK IN HIGH SCHOOL MATHEMATICS COURSES: A COLLECTIVE CASE STUDY
Sharon B. Owens
Liberty University
School of Education

You are invited to be in a research study on synchronous technology and corrective feedback in high school mathematics course. You were selected as a possible participant because teach at a high school math course at Morrison Academy. The school's superintendent and the campus principal have provided permission for you to be contacted. Please read this form and ask any questions you may have before agreeing to be in the study.

Sharon Owens, a doctoral candidate in the School of Education at Liberty University, is conducting this study.

Background Information: The purpose of this study is qualitative collective case study research is to examine synchronous technology and corrective feedback in high school mathematics courses.

Procedures: If you agree to be in this study, I would ask you to do the following things:

1. Join virtual interview that will be approximately 30 minutes long. The interview will be recorded and be conducted over Zoom.
2. Allow the researcher to conduct a Classroom Observation. The researcher will observe your interaction with online platforms. This observation will be approximately 40 minutes. A follow-up interview may be necessary after classroom observations are conducted.
3. Join a virtual focus group that will be approximately 30 minutes long. The focus group interviews will be approximately 30 to 40 minutes.

Risks: The risks involved in this study may include loss of confidentiality. The participant's rights are to be protected, and the preservation of their identification and dignity will be maintained and be confidential. To minimize the risk of loss of confidentiality, the researcher will collect personal information that is absolutely essential to the research. The coding of personal data will be securely stored, and only the researcher and dissertation committee will only have access to it. The identities of the participants will never be released.

Benefits: Participants should not expect to receive a direct benefit from taking part in this study.

Benefits to society include educators, administrators, and the wider public to have an increased understanding of the educational experiences of implementing technological resources. This study is also applicable for curriculum specialists when choosing resources that may be implemented in specific courses. Maybe they will consider some of the aspects of the data when selecting specific resources for the curriculum. This may also be applicable for instructional coaches as they support teachers through the implementation process, significantly when philosophy or pedagogy changes.

Compensation: Participants will not be compensated for participating in this study.

Confidentiality: The records of this study will be kept private. In any sort of report, I might publish, I will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records. I may share the data I collect from you for use in future research studies or with other researchers; if I share the data that I collect about you, I will remove any information that could identify you, if applicable, before I share the data.

- Participants will be assigned a pseudonym. I will conduct the interviews in a location where others will not easily overhear the conversation and on a virtual platform.
- Data will be stored on a password locked computer and may be used in future presentations. After three years, all electronic records will be deleted.
- Interviews will be recorded and transcribed. Recordings will be stored on a password locked computer for three years and then erased. Only the researcher will have access to these recordings.
- I cannot assure participants that other members of the focus group will not share what was discussed with persons outside of the group.

Conflicts of Interest Disclosure:
The researcher serves as a professional learning coach for Morrison Academy Taichung. To limit potential conflicts the researcher has no authority or direct connection with the high schools or high school math departments. This disclosure is made so that you can decide if this relationship will affect your willingness to participate in this study. No action will be taken against an individual based on his or her decision to participate in this study.

Voluntary Nature of the Study: Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Liberty University or Sharon Owens. If you decide to participate, you are free to not answer any question or withdraw at any time

How to Withdraw from the Study:

If you choose to withdraw from the study, please contact the researcher at the email address/phone number included in the next paragraph. Should you choose to withdraw, data collected from you, apart from focus group data, individual interviews and classroom observations will be destroyed immediately and will not be included in this study. Focus group data will not be destroyed, but your contributions to the focus group will not be included in the study if you choose to withdraw.

Contacts and Questions: The researcher conducting this study is Sharon Owens. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at [redacted] or [redacted] You may also contact the researcher's faculty chair, Dr. Wesley Scott at [redacted].

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA 24515 or email at irb@liberty.edu.

Please notify the researcher if you would like a copy of this information for your records.

Statement of Consent: I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

☐ The researcher has my permission to video-record me through Zoom as part of my participation in this study.

By typing your name and date below you are granting permission to be a part of this study.

____

Signature of Participant Date

____

Signature of Investigator Date

Appendix G

Appendix G: Demographical Survey

Note to reader: The actual Google Form questionnaire is produced and delivered to the recipient in digital format via e-mail and features interactive check-boxes and expanding blank spaces for written answers.

1. What is your age?
    a. 18-25
    b. 25-30
    c. 30-35
    d. 35 or older
2. What is your gender?
    a. Male
    b. Female
    c. Prefer not to respond

3. Please specify your ethnicity?
    a. Asian
    b. Black or African American
    c. Hispanic or Latino
    d. Native American or Alaska Native
    e. Native Hawaiian or Pacific Islander
    f. White
    g. Race and Ethnicity Unknown
    h. Other(please specify)
    i. Prefer not to respond

4. What is the highest degree attained?
    a. Some college credit, no degree
    b. Associates degree (for example: AA, AS)
    c. Bachelor's degree (for example: BA. BS)
    d. Master's degree (for example: MA, MS, MEng, MEd, MSW, MBA)
    e. Doctorate degree (for example, PhD, EdD)
    f. Prefer not to respond

5. How many years have you been teaching?
    a. 0-5 years
    b. 5-10 years
    c. 10-15 years
    d. 15 or more
    e. Prefer not to respond

6. What type of teaching certification do you hold?
    a. Regular or standard state certificate or advanced professional certificate

b. Temporary certificate (requires some additional college coursework and/or student teaching before regular certification can be obtained)
c. Regular or full certification by an accrediting or certifying body (ACSI, etc.)

7. Did you have a major, minor, or special emphasis in any of the following subjects as part of your undergraduate or graduate coursework?

Mark one on each row.	**Yes, a major**	**Yes, a major or minor special emphasis**	**No**
a. Mathematics education	☐	☐	☐
b. Mathematics	☐	☐	☐
c. Other mathematics-related subject such as statistics	☐	☐	☐
d. Elementary or secondary education	☐	☐	☐

8. What is your school name and campus location?
    a. Morrison Academy Taipei
    b. Morrison Academy Taichung
    c. Morrison Academy Kaohsiung

9. What is your official title at your current institution?

10. What high school mathematics course(s) do you currently teach?

11. How many years have you taught high school mathematics?
    a. 0-5 years
    b. 5-10 years
    c. 10-15 years
    d. 15 or more

Appendix H

Appendix H: Individual Interview Questions

1. How would you describe your ways of providing feedback to your students?
2. How often do you use computers during class lessons?
3. What math platforms do you ask your students to utilize during a unit?
4. What is your current method to provide corrective feedback to your students?
5. How do you think online synchronous platforms such as Demos providing real-time corrective feedback differ from you providing corrective feedback to your mathematical students?
6. Please describe, with as much detail as possible, how the online platforms support your student’s learning.
7. How were your students engaged in the learning content when they were using the platform?
8. Describe how the online platform was implemented.
9. What professional development experiences have you had that prepared you to work with online mathematics platforms as a teacher?
10. Would you want to make any changes to the program or training that you received?
11. What else would you like to add to our discussion of your experiences with corrective feedback or online platforms that we haven’t discussed?

Appendix I

Appendix I: Focus-Group Questions

1. How would you describe your ways of providing feedback to your students?
2. How has technology provided opportunities for you to provide real-time synchronous feedback to your students?
3. Is there any other information that you would like to add or share with the group?

Appendix J

Appendix J: Sample Observation Field Notes

Observational Protocol	
Setting: High School Math Classroom (Geometry)	
Role of Researcher: Non-participant	
Length of observation: 1:00-1:45 PM AM Thursday, March 17, 2022	
Descriptive Notes	Reflective Notes
1:00: The class starts with the teacher walking around and checking the assessment corrections given previously. He told the students he was checking the corrections and providing feedback to individual students. He reminded the students of the school's grading policy and told them that they could receive additional support during 3R (study hall) if needed. He reminded them about filling out the Google Form. 1:10: The teacher asked the students to take out their graphing devices. He used an iPad to display the learning standards and math	The teacher described the way of providing feedback during his interview. This explanation was demonstrated during this time of the class. The teacher provided corrective feedback to the students. The students showed attention to the teacher during the demonstration. The students had a variety of devices present during the class

examples. He used an application (Goodnotes) to demonstrate the graphs.	(laptops, graphing calculators, iPads, and smartphones).
1:15: Some students found difficulties in understanding the presented concept. The teacher asked several students to demonstrate a problem for others (peer collaboration). During this time, the teacher helped two students with the problem. After the students seemed to understand, the teacher asked them to explain their mistakes to the others.	Some students needed more support than others, and the teacher provided immediate correctives during class. During peer collaboration, the students were responsive and a sense of responsibility for their learning was shown.
1:30: The teacher continued to demonstrate examples of the work, providing solutions to the problems. The students who believed they could continue on their own were asked to work on the problems, and the work was shared with them through a Google Form.	The students were engaged during the explanation and used their devices to work on the problems. The Google Form had problems; the form automatically graded the submission as the students completed the solutions and submitted their responses. If the submission was incorrect, a video was presented with additional feedback.

1:45: Before class was finished, the teacher reminded the students that they needed to finish the practice work before the next class. He also reminded them they could have additional practice using IXL.	During the individual interview, the teacher explained how he used the Google Suite applications. He used Google Forms to provide corrective feedback and gather data to provide students with additional feedback. Additionally, his description of IXL was demonstrated during the closing remarks.

Appendix K

Appendix K: Research Question Worksheet

Theme 1: How do high school mathematics teachers implement and use online learning platforms that provide real-time corrective feedback?
Theme 2: How do high school mathematical educators describe their interactions with the synchronous platforms that provide real-time corrective feedback?
Theme 3: How do mathematics teachers perceive the support level of synchronous, online corrective feedback in high school mathematic courses?

Appendix L

Appendix L: Notes Worksheet

Case Identifier: Site 1

Synopsis of the Case:
Three teachers

Pseudo	Gender	Race	Years taught	Degree	Content area	Grade level
Tom	Male	Caucasian	15+	Masters	Algebra 1	9-12
Sally	Female	Asian	15+	Bachelors	Algebra 1	9-12
Sam	Male	Asian	15+	Masters	Algebra 1	9-12

Case Findings:
RQ1 Tags
Technology skills – High knowledge
Technology skills – Moderate knowledge
Technology skills – Low knowledge
Corrective Feedback – Attitude
Corrective Feedback – Informal
Corrective Feedback - Formal
Best practice
Integration
Self-taught
Implementation - Desmos
Implementation - IXL
Implementation - Google Suite
Implementation - Other

RQ2 Tags
Platform - Negative
Platform - Positive
Platform - High interaction
Platform - Moderate interaction
Platform - Impact on cognition
Platform - Contribution to learning process (platform data)
Student Interaction – Positive (motivation)
Student Interaction – Negative (motivation)

RQ3 Tags
Support - Negative
Support - Positive
Institutional - Time limitations
Institutional -Lack of support
Institutional – Professional learning

Possible Excerpts for the Multi-case Report:

“I decided to use IXL and the reason why is because I can watch all the students in real-time. I can see which ones they are missing because IXL gives them immediate feedback. That was quite rewarding for me to see how engaged they were by using that platform and for me to have the real-time assessment of their abilities.” (Tom, Individual Interview)

I was like, Oh, my goodness, you spent how long on this? And then I talked to her, and we sat down one-on-one, and I could help her more than the computer program. And then she was good. I think it was the next day after I saw how long she spent on IXL that I was shocked. (Sam, Individual Interview)

"I decided to use IXL, and the reason why is because I can watch all the students in real-time." (Tom, Individual Interview)

“The thing that's nice about IXL's SmartScore is you can actually see the score by a question, what the students are doing wrong. I would use the score if they had spent a lot of time and the score didn't reflect a solid enough understanding, then I go in and see what they're missing and ask myself if it's computational errors or they don't understand it at all. It's very useful data.” (Sam, Focus Group)

“So, I kind of saw it was a combination of learning it from colleagues and actually trying it out, too. And seeing how that goes, it has also developed throughout the months, the previous months, because I started out with the free version and realized, oh, it is limited, and I need to delete videos I have made. So it was good that our ETCs listened to us and asked for the pro version.” (Sally, Focus Group)

Appendix M

Appendix M: Merged Findings Worksheet

Merged Findings	From Which Case(s)	Themes		
		1	2	3
Implementing new platforms, long planning periods take place.	A, B, C	X		
The platforms need to previewed before assigning the work to the student.	A, B, C	X		
Integrating technology that provides synchronous corrective feedback into classroom learning environments is considered part of best practices for student learning.	A, B, C	X		
Teachers want to use platforms that given students individual practice that supports mastery of the content taught.	A, B, C	X		
Platforms are implemented based on a recommendation from a colleague.	A, B, C	X		
First interactions with the technology are self-taught with minimal support.	A, B, C	X		
The platforms that provide synchronous corrective feedback to identified learning gaps as data exposed deficit skills.	A, B, C		X	
Technology can be a functional tool to individualize the practice for mastery.	A, B, C		X	
Technology is a great tool for students to gain exposure to new content.	A, B, C		X	
Technology that provides immediate feedback is a challenge for mathematics classes because artificial	A, B, C		X	

intelligence cannot differentiate between computational errors or lack of conceptual understanding.				
Students become discouraged and motivation decreases because the platforms are unable to differentiate between the levels of understanding.	A, B, C		X	
Institutional support was minimal.	A, B, C			X
Lack of professional development was offered by institution	A, B, C			X
Lack of professional development offered by resources.	A, B, C			X
Time limitations for colleague collaboration.	A, B, C			X
Time limitations for professional development.	A, B, C			X

Multiple Case Study Analysis, Robert E. Stake. 2006. Copyright Guilford Press. Reprinted with permission of The Guilford Press. Adapted from Worksheet 5B.

Appendix N

Appendix N: Assertions Worksheet

Designator	Assertions	Related to Which Research Question	Which Case(s)
1	Implementing a selected platform that provides synchronous corrective feedback requires long planning periods, and the platform must be previewed before assigning the work to the student.	1	A, B, C
2	Integrating technology that provides SCF into classroom learning environments is considered part of best practices for student learning by giving students individual practice that supports mastery of the content taught.	1	A, B, C
3	A large percentage of the teachers expressed that they implement a specific resource without prior knowledge of the platform, and most teachers are using a platform based on a recommendation from a colleague.	1	A, B, C
4	The first interactions with the technology are self-taught with minimal support.	1	A, B, C
5	By using the platforms that provide synchronous corrective feedback to identify learning gaps as data exposed deficit skills is useful for student learning.	2	A, B, C
6	Technology is a great tool to individualize the practice for mastery and to gain exposure to new content.	2	A, B, C
7	Technology that provides immediate feedback is a challenge for mathematics classes because artificial intelligence cannot differentiate between computational errors or lack of conceptual understanding.	2	A, B, C

8	Students become discouraged and motivation decreases because the platforms are unable to differentiate between the levels of understanding.	2	A, B, C
9	Proper implementation and usage henges on effective professional development.	3	A, B, C
10	Providing time within the working hours to collaborate with colleagues would be more beneficial than systematic professional development.	3	A, B, C

Appendix O

Appendix O: Sample Individual Interview

Interviewer	Okay, so thank you again for joining my study. This is our first question; how would you describe your ways of providing feedback to your students?
Tom	I think, because I employ the flipped classroom, that means I videotape my lessons ahead of time. And so, the students do that for homework, they'll watch the lesson, and the key points and and fill out a worksheet. So, I have a worksheet for them to fill out that goes along with the video that they're watching. And so, in class, I'll go around to the students, because typically, there are a couple of students that take a little bit longer to grasp some of the concepts. So, I'll go through the overview them first and make sure that they are on task and proceeding. Because as you know, in the math classes, it usually gets progressively more difficult. As you go through the questions. The first questions are usually easier. So, I'll go with them, just make sure they understand the concepts, and then I'll go through. So, visit every one of my students that way. Of course, some of the students don't require or even desire, someone looking over their shoulder. And so, it depends on the personality and the needs of my students as to what kind of feedback they get.
Interviewer	How often do you use computers during your lessons?
Tom	Probably every lesson, we will use the computer.
Interviewer	What math platforms do you ask your students to use during your units?
Tom	We probably the one we use most frequently is IXL. And then everything else goes on Google Classroom. So that will have the video that I posted for them to watch. And I will give them a handout from the textbooks that we have the textbooks also come up come with a handout, and I will print those off and give them to the students.
Interviewer	In all of the flipped classroom videos, are you creating them or are you finding them and then using them? Or are you both, creating and finding them?
Tom	I really haven't read reached the stage where I am finding ones that are exactly what I want. So up to now, I've been doing it myself. But I imagine there's someone out there who does it in a much more attractive and interesting manner. If I come across them, I will be sure to implement their lessons into my lesson.
Interviewer	Could you could you could you describe how you provide corrective feedback to your students?
Tom	Okay, so for example, the best way is once I have collected their homework, and I've gone over it, then the next time we have class, I have an idea of where the student is struggling. And so usually the the problem will present itself, it will be clear that they're struggling with one type of skill or another. And so,

for example, perhaps they don't understand how to use negative numbers appropriately. You know, they may not know how to change signs or something like that. And so, I'll notice that. And so, then I'll go over to that student, and we'll go over the ones they missed, and we'll talk about it. I use this also with assessments. This past week, one of the students, she's so stressed when she takes tests. And so, she had missed, she had missed a couple problems. So, I went over with over the test with her. We talked about it, I asked her and had her explained to me how to do it. And so, she satisfied me that she knew how to do it without actually having to take pencil in hand and rewrite it on a piece of paper. And in fact, I got her to do more by asking her several questions and having her explain everything to me. And I got more information from her than I would have if I just asked her to fill out another test sheet.

Appendix P

Appendix P: Sample Focus Group Interview

Interviewer So, could each of you please describe how you implemented in the synchronous technology that you are using in your classrooms?

Sally Okay, I am going to go ahead first; like what I said in the questionnaire that you gave, I use EdPuzzle. In the classroom as well, I know some of the teachers here use that for a homework task in order to learn the lesson and then have in-class work to go along with it. But in my case, I also use that puzzle within class time and monitor their activity. And while we're going through that, in the class, I go around and entertain questions if they have any, and then use the concepts that they learned from at Basel as they jump into in class work right after.

Tom As you know, I use IXL and also, and I use a flipped classroom. So, there is a video for them to watch. But what I do is I pair that with examples that they are going to see immediately on Google Classroom. I have shared with them because I want to make sure that they are paying attention to me first. Rather than just going to the worksheet, pausing the video screen, and copying down the way I have worked it out. And so, what they do is they are not allowed to use it; they are not allowed to do anything on the screen until after they have watched the demonstration in class. And we've gotten through it. And we've worked on a problem exactly like they're going to see but with different numbers. So, I use both of those things, IXL and a video.

Sam Okay, so I think for myself, we are talking about synchronous learning. I will just talk about like PowerPoint or Jamboard as an example. I think when I want them to work on something, I create a pre-template for them to work off of. And then, I also do like an example of the assignment. So, there is a lot of explaining at the beginning, you know, like, this is the standard, or this is the skill we are trying to look at and master. And then, if I have planned well enough, I will do my own example slide, like, say, for Jamboard or PowerPoint. And then they can use a different slide to create their own example maybe or work off the examples that I have given them. And they can do that independently, or sometimes I pair them up to do that kind of work. Then for the IXL, I would say, again, in terms of implementation, the first thing was trying to get on the same page of what the SmartScore should be. Also, clarify how to do the work, you know, don't just like randomly try to guess it and do it in your head, but show your work, whether it is on a whiteboard or a piece of paper. So, they are not really just trying to get through and get that score right away. But they are trying to pause and kind of show their learning to me. And I will sometimes randomly check this check it to make sure they are doing it not just in their head, but they are actually writing things down and not trying to power through it, kind of with mental math or something like that.

Tom You know, just what Sam said was something very interesting. When I use IXL, it is usually with problems that they have no choice but to have a scratch piece of paper beside them to do the work. That is not something they can do in their heads. So, for example, like the area that we are working on, now, they have to divide up that figure into small roles, and we have to write all that down; it wouldn't be possible for them to do it in their head. And so, the best a very good point that Sam makes, we do make some changes according to what work they can do. If I feel that IXL is just something they can do in their head, then I probably refer to the homework sheets as more valuable.

Appendix Q

Appendix Q: Copyright Permissions

I received the following email in response to my request to republish the flow chart that demonstrates the technology-mediated instruction from Bush (2020).

From: Jeffrey.Bush@colorado.edu
Subject: Re: Dissertation Flow Chart-Permission to Use
Date: September 21, 2021 at 1:34 PM
To: Sharon Owens

Hi Sharon,

Yes! Feel free to use it for non-commercial purposes but please cite it appropriately. I'm putting together a manuscript for journal publication that will also use it and I can send that along to you when it is available if you would rather cite a journal than a dissertation in the future.

Best,
Jeff

Appendix R

Appendix R: Copyright Permissions

I received the following email in response to my request to republish Bloom's Mastery Learning Model from Betts (2019).

From: Anastasia Betts
Subject: Re: Bloom's Mastery Learning Model-Permission to Use
Date: September 21, 2021
To: Sharon Owens

Hi Sharon,

You can absolutely use my figure, with proper citations to the paper. Let me know if you want me to send you the higher resolution jpeg, which will give you a better cleaner image than if you just copy paste from the paper.

Anastasia Betts

Appendix S

Appendix S: Copyright Permissions

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