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An Examination of the Use of Computer-Based Formative Assessments

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AN EXAMINATION OF THE USE OF COMPUTER-BASED FORMATIVE ASSESSMENTS

by

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(Under the Direction of Juliann Sergi McBrayer)

ABSTRACT

In one-to-one computing settings the teacher's own internal beliefs and attitudes will primarily determine how often and in what ways they will use technology with their students. Although a great deal of literature addresses the barriers that teachers face when utilizing technology, the majority of these studies investigated technology use very broadly. The purpose of this quantitative, correlational study was to investigate the computer-based formative assessment (CBFA) practices of 414 core academic teachers within a one-to-one computing environment in a mid-sized suburban school district to better understand the relationships between CBFA usage rates of teachers and their background and perceptions of instruction technology. Survey data were collected from 261 of the academic teachers (63% response rate), which quantified teacher CBFA usage rates and collected information on teacher demographic factors, class factors, and teacher perceptions about technology as well as teacher autonomy. The major findings of the study indicated that there were statistically significant correlations between CBFA usage rates and teacher comfort with technology, teacher belief in technology as well as forms of teacher autonomy. Significant differences in CBFA usage rates were found between different subjects, class levels, grade levels, and for teachers that have state-mandated end of course assessments. The findings from this study provide more insight into how teachers are utilizing CBFA in their classrooms and can aide in developing targeted professional development activities to support teachers in using technology to formatively assess students. Future research into the effectiveness of increased CBFA usage on student achievement could extend this research to demonstrate how student achievement may be related to increased use of this instructional tool.

INDEX WORDS: Formative assessment, Computer-based formative assessment, Barriers to technology, Teacher beliefs, One-to-one computing

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DEDICATION

What a journey! The many long hours of class work and traveling to school are over. The road was not easy and I couldn't have done this without the wonderful support of my family and friends. I dedicate this dissertation to my wife Michelle who gave me the encouragement to start my doctoral program and provided me with endless love and patience as I spent so much time away from family during this process; to my sons, I hope I have set a good example for you to follow in your educational journey; to my dad, who reminds me how proud he is of my accomplishments; to my mom, who was always my cheerleader and my compass, I will miss you, I know you are looking down with love; to all my friends, coworkers, and cohort members who listened to me go on and on about my dissertation and gave me words of hope that I could complete this and not give up.

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CHAPTER ONE

INTRODUCTION

Of the many instructional methods that teachers may choose to use in the classroom, formative assessment has been shown to be a promising tool to increase student achievement and motivation (Andersson & Palm, 2017; Black & Wiliam, 1998b; Cauley & McMillan, 2010; Faber et al., 2017; Irving, 2015; Meusen-Beekman et al., 2016). The use of formative assessment within the classroom can be an effective method of monitoring and adjusting instruction if used with frequency and fidelity (Andersson & Palm, 2017; Black & Wiliam, 1998a). While research is readily available and the importance of using formative assessment during the instructional phase well documented, in practice, teachers are not using formative assessment adequately to realize the full potential impact of the practice (Cotton, 2017; Missett et al., 2014; Wiliam, 2011).

Furthermore, even after teachers are exposed to formal formative assessment training, there still often remains, “a disconnect between research and practice” (Box et al., 2015, p. 957). Additionally, teachers understand what they should be doing, yet often fail to do so in practice. Formative assessment requires the timely analysis of student assessment data to determine the current level of understanding of each student in the classroom (Greenstein, 2010). Feedback based on this analysis should be provided to the learner and should be specific to the deficit of knowledge for each student. Facing the restrictions of the typical classroom teacher to gather this information and make adjustments in real time, this process can be difficult to implement frequently with all students and may partially explain the disconnect (Box et al., 2015). Teachers continue to struggle to maximize the potentials of formative assessment within their classrooms for a variety of reasons. These reasons may be grounded in items such as internal teacher belief systems about how students learn as well as external pressures some teachers feel to cover material or teach to the test rather than implementing formative assessments regularly (Box et al., 2015). As a result, formative assessment theory does not always translate into teacher formative assessment practice in the classroom (Cotton, 2017, Missett et al., 2014).

In the last several years, technological advances such as classroom response systems (CRS), wireless internet access capabilities, networked classrooms have become ubiquitous in many schools (Johnson, 2016; Lee et al., 2012). CRS was one of the first uses of technology-enhanced formative assessments used by teachers and students in the classrooms. These systems allowed the teacher to pose questions to the class and through a student response system often referred to as a clicker, were able to poll the class in real time to gather assessment data quickly so that the teacher could provide relevant feedback (Lee et al., 2012). Recently, inexpensive personal computing devices such as the Google Chromebook have entered the market and have advanced technology access in classrooms even further (Molnar, 2014).

Additionally, widespread availability of a variety of interactive web-based applications known as Web 2.0 Tools has increased the formative assessment options for teachers and students (Bower, 2016; Singer, 2017). Many school systems have taken advantage of this opportunity by purchasing networked computing devices for each student to take home and/or to use daily (Fleischer, 2017; Kennedy et al., 2016; Zheng et al., 2016). This is known as a one-to-one computer to student ratio. One-to-one computing access has been shown to have positive effects on achievement in the areas of science, writing, mathematics, and English when teachers utilize the technology for instructional purposes (Zheng et al., 2016). In schools with a one-to-one networked computer ratio and ready access to Web 2.0 tools, Computer-Based Formative

Assessment (CBFA) use is now largely a choice by the teacher to utilize the tools rather than a limitation on the availability of the technology.

With a networked device for every student and a wide range of free applications available online for teachers to choose from, access to the technology is often no longer a barrier to implementation in many schools. While it seems likely that teachers in this type of setting would choose to use these tools in their classrooms, teachers still face barriers when incorporating technology into their classroom instruction. Teachers face barriers such as their own beliefs related to technology, their technology self-efficacy, their level of technology professional learning, and ongoing technology support. Overcoming these barriers has been reported to be essential for successful technology integration in the classroom and may be related to the frequency of technology usage by teachers (Blackwell et al., 2014; Ertmer et al., 2012; Heath, 2017; Hsu, 2016; Kopcha, 2012; Minshew & Andersson, 2015). Ultimately, when teachers perceive Web 2.0 tools as useful to facilitate student learning and have a high level of self-efficacy in the use of these tools, their intentions to use the tools in their classrooms have been shown to translate into actions (Sadaf et al., 2016).

Background

The review of the literature will begin by examining the theoretical framework of this study as well as the legislative and policy mandates for teacher usage of formative assessments in Georgia. The literature on formative assessment theory will be reviewed in addition to the impact of formative assessment on student achievement, barriers to implementing formative assessment practice in the classroom, and the effect of professional learning and collaboration in overcoming those barriers. The evolution of educational technology will be examined followed by an exploration into the external and internal barriers that teachers face when implementing technology into the classroom. One-to-one computer initiatives will be reviewed to determine the impact on student motivation and learning. The review will continue by investigating the effectiveness of the use of computer-based feedback on student achievement. The review will conclude with a discussion of computer-based formative assessment applications that are available to students and teachers, their impact on classroom practices, and the potential for these applications to advance student achievement when paired with instant formative feedback.

Theoretical Framework

The theoretical framework guiding this study stems from formative assessment theory (Black & Wiliam, 1998a, 1998b), and instructional technology theory (Ertmer, 1999). Formative assessment theory evolved from the early work of Michael Scriven who began the discussion of the differences of summative evaluations and formative evaluations in 1966 (Stiggins, 2005). The basis of formative assessment theory holds that teachers should be frequently assessing student learning through the use of non-graded measures to diagnose the achievement levels of their students (Black & Wiliam, 1998a). These measures are then used to inform the next instructional steps (Greenstein, 2010). When these practices are carried out with consistency and fidelity, formative assessment has been shown to positively impact student achievement (Black & Wiliam, 1998a, 1998b). The instructional technology theory of Ertmer (1999) holds that teachers face two district types of barriers to implementing technology. These barriers will either derive from factors that are external to the teacher or internal to the teacher.

External barriers, or "first-order" barriers, include such things as access to technology, student ability, professional learning and support for teachers, and the space and time to use the technology. In recent years, with the widespread integration of technology and internet access in schools nationwide, many external barriers have been reduced or eliminated (Kopcha, 2012).

Internal barriers, or "second-order" barriers refer to the teachers' own beliefs and attitudes about using technology. These second-order barriers have been shown to be the primary barrier to instructional technology use by teachers (Hew & Brush, 2006). It will be these beliefs and attitudes that this study will investigate as they relate to the frequency of use of computer-based formative assessments by teachers in the classroom.

Mandating Formative Assessment Usage

Through a series of legislative initiatives from the Federal government down to the state level, student achievement accountability measures have become a top priority for lawmakers and have taken on increased importance in the past several years. As a result of these initiatives, efforts to identify instructional strategies that will positively impact student achievement have led to a renewed interest in formative assessment (Greenstein, 2010; Irving, 2015; Wiliam, 2011). Specifically, the state of Georgia has incorporated teacher use of formative assessments as a major component of its current teacher evaluation system and mandates its use in the classroom (Georgia Department of Education [GADOE], 2014).

The origins of the modern education reform movement in the United States can be traced back to a 1983 report entitled, A Nation at Risk, which found that achievement measures for students in the United States lagged far behind other nations thus putting the country in jeopardy of losing its standing in the international community (National Commission on Excellence in Education 1983). As a direct result of this report, a sounding of the alarm was raised for educational reform in this country. What followed was a call for accountability measures, higher standards in our educational system, and a focus on student computer skills (Culp et al., 2005). Some twenty years later, the No Child Left Behind Act (NCLB) of 2002 was passed, which put federal educational mandates on all states and sought to incorporate many of the recommendations from the 1983 report. The key component of the legislation included a mandate for standardized testing and student achievement targets to measure the effectiveness of schools (Croft et al., 2016). These achievement targets increased over time and would have ultimately reached 100% of students being required to test as proficient by 2014. This unrealistic goal put enormous pressure on teachers, administrators, and school systems to ensure that students would perform well on these high stakes tests to avoid punitive measures (Ravitch, 2010).

As the 2014 deadline approached, President Obama, in an effort to provide relief from NCLB, introduced the Race to the Top Grant (RTT) so states could apply for exemptions from the NCLB requirements (Culp et al., 2005). This competitive grant required states to devise their own comprehensive education reform plan proposals. These proposals had to include specific requirements that would be evaluated against other state plans in order to compete for a portion of the grant award. These plans would be evaluated on how well they addressed "student achievement, closing achievement gaps, improving graduation rates, and ensuring students are prepared for success in college and careers" (US Department of Education [USED], 2012, p. 2). In 2010, the state of Georgia was awarded a $400 million RTT grant and began the multi-year process of implementation of the state's accountability plan. In 2015, the Every Student Succeeds Act (ESSA) was passed as a replacement to NCLB. ESSA relaxed many of the prior requirements from NCLB and allowed states more autonomy to set standards, although accountability through standardized testing remained as a central focus of the legislation.

Two of the components of Georgia's RTT plan included a new statewide performance-based teacher evaluation system and the creation of a student longitudinal data system (SLDS) to record all test score achievement data for students across the state (USED, 2012). The teacher evaluation system was based on research, which sought to quantify the yearly impact of a teacher on student achievement (Stronge et al., 2011). The evaluation system entitled, the Teacher Keys Effectiveness System (TKES), added a new evaluation instrument called the Teacher Assessment of Performance Standards (TAPS) as well as student test score comparisons based on data from SLDS. This measuring system uses SLDS data to assign a percentile growth rank to each student, and in turn to each teacher, for the purpose of comparing the teacher's effectiveness to other teachers across the state at increasing test scores, and thus measuring the "value" that the teacher added to the achievement equation (Stronge et al., 2011). The comparative measure of student performance is called the Student Growth Percentile (SGP) and it provides a quantifiable measure of teacher performance based on how their students perform on the end of the year assessments (GADOE, 2020). Additionally, the results of each of these components are combined and results in each teacher receiving an overall Teacher Effectiveness Measure (TEM) score at the end of each academic school year.

In 2013, in another educational policy shift, the GADOE announced that it would replace all current standardized testing with a new single statewide assessment called the Georgia Milestones. The new assessment system would continue to be used for accountability purposes for educators as required by TKES. Along with the new assessment system, the GADOE announced a timeline for districts across the state to transition to fully online testing within five years (GADOE, 2014). This impacted school district technology funding decisions in a significant way and led districts to focus on technology integration and infrastructure improvements across the state (Croft et al., 2016).

School administrators use TAPS to provide ongoing feedback to teachers in order to guide instructional practices. TAPS consist of ten performance standards, which are listed in

Appendix A (GADOE, 2020). Of specific interest to this study is the prominent inclusion of formative assessment throughout the new performance standards. Black and Wiliam (1998b) defined formative assessment as “all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged” (p. 8). Formative assessment is mentioned either directly or indirectly in six of the ten Georgia Performance Standards, those being standards two, three, four, five, six, and eight (GADOE, 2020). With such an emphasis on formative assessment now part of each teacher’s formal evaluation process, teachers in Georgia are clearly expected to understand and apply this instructional method in their classrooms.

Formative Assessment

The frequent use of formative assessments has been shown to have a significant positive impact on student motivation and learning (Black & Wiliam, 1998a; Cauley & McMillan, 2010). Recognizing the impact of formative assessment on student achievement, the GADOE now requires teachers to regularly use formative assessments in their classroom practice, and for administrators to systematically evaluate teachers on its use under the new evaluation system known as TKES (GADOE, 2020). Formative assessment is different from summative assessment in that it typically occurs during the instructional portion of the lesson to guide the instructional decisions (Stiggins, 2005; Wiliam, 2011), rather than at the conclusion to measure student mastery (Cauley & McMillan, 2010; Harlen, 2007).

Despite mandates for the use of formative assessment and the impact that it has on student achievement, many teachers still face barriers to implementing formative assessment in their classrooms (Andersson & Palm, 2017; Cotton, 2017; De Lisle, 2016). These barriers include access to professional learning on the use of formative assessments, the teachers’ own personal beliefs and assumptions about formative assessment use, their belief concerning student ability, and time constraints to conduct formative assessments and provide immediate feedback to all students (Box et al., 2015; Ertmer et al., 2012; Powell & Kusuma-Powell, 2015). Research has shown that these barriers can be addressed through targeted professional learning (Andersson & Palm, 2017), and by providing teachers with autonomy and support from school leadership (Birenbaum et al., 2011, De Lisle, 2016; Hollingworth, 2012).

Technology in Education

The educational use of computer technology has occurred at a steady pace over the last forty years beginning with the birth of the internet in the 1980s. Early efforts to harness the educational power of computers primarily focused on equipping schools with desktop computer laboratories which were expensive, were outdated very quickly, and created issues of access for students and teachers as they had to schedule specific times to use the facilities. Additionally, technological issues such as non-functioning hardware or unreliable internet access meant that access to the technology was not assured (Ertmer, 1999). To address this issue of access and in an attempt to put technology into the hands of more students, recent efforts have included the use of portable networked laptops, handheld devices, and most recently inexpensive laptop devices (Parson, 2017). These inexpensive laptop devices have allowed many school systems to make the decision to purchase enough of these devices to provide one for every student which is referred to as a one-to-one ratio (Varier et al, 2017; Zheng et al., 2016).

Concurrent with the advancement of computer hardware has been the rapid expansion of access to high-speed wireless internet in schools (Wells & Lewis, 2006) and the availability of a large number of web-based applications called Web 2.0 tools. While some of these applications require a paid subscription, many of these applications are free to use by the teacher and students

(Bower, 2016). Among these tools are numerous applications that allow teachers to use the technology to quickly assess student learning and provide instant formative feedback to students. Despite this availability, there still exist certain barriers to using the technology for this purpose.

First-Order Barriers to Technology

Many early first-order barriers to computer technology access that schools and district faced have been eliminated. These included such things as the cost of the devices, access to the internet, the space for computer laboratories, as well as student technological abilities (Blackwell et al., 2014; Ertmer, 1999; Hew & Brush, 2006; Tas, 2017). While these barriers have largely been eliminated, there still remain certain external barriers that hinder the teacher use of instructional technology with their students. Student computer ability as perceived by the teacher has been shown to impact a teacher’s decision to use technology with their students, with teachers avoiding technology when they feel that student computer skills or their behavior will hinder their success (Heath, 2017; Hsu, 2016).

Teachers also continue to report that they lack the time, resources, and training to use technology for instructional purposes (Ertmer et al., 2012; Hsu, 2016; Kopcha, 2012). In addition, teachers with different backgrounds and experience levels will tend to use technology at different rates and may need different levels of support in order to utilize instructional technology (Blackwell et al., 2014; Hsu, 2016). These barriers have been found to be greatly reduced or eliminated when teachers are provided with situated professional learning and collaborative support in the use of instructional technology (Blackwell et al., 2014; Ertmer et al., 2012; Heath, 2017; Hew & Brush, 2006; Hsu, 2016; Karatas et al., 2017; Kopcha, 2012). Thus, school leadership must ensure that ongoing professional learning and collaborative support is present within their schools to support teacher usage of technology. Lastly, the use of professional learning communities (PLC) has been found to be an effective means to accomplish this support (Hollingworth, 2012).

Second-Order Barriers to Technology

While first-order barriers have been greatly reduced in the modern classroom and support can further reduce these barriers, there are second-order barriers that remain. These barriers are primarily derived from the teacher's internal pedagogical beliefs, assumptions about technology in education, and their self-efficacy with technology. Specifically, these beliefs include teacher fear of the technology, lack of knowledge about the technology, and uncertainty about the effectiveness of the technology to ensure favorable learning outcomes, especially on standardized tests (Ertmer et al., 2012). Research on the beliefs that teachers hold about technology have shown that this is the true gatekeeper to technology integration by teachers (Hew & Brush, 2006). To assist in overcoming these barriers, school leaders must establish a common technology vision, they must provide teachers with opportunities to collaborate with other teachers on technology integration, and they must provide ongoing professional development using the same technology tools that teachers are expected to use (Ertmer et al., 2012; Heath, 2017; Hew & Brush, 2006; Kopcha, 2012).

Often when teachers avoid using technology, fear of the technology may be a factor. In many cases the teacher's fear of the technology is derived from their concern that they will not be able to troubleshoot the technology if something does not work correctly or that the technology will not be as effective as other methods of instruction (Ertmer et al., 2012). Teachers that hold positive beliefs about technology will work through second-order barriers to ensure that their students can have access to technology (Heath, 2017). In these situations, it is lack of confidence and knowledge on the part of the teacher that seems to play the largest role in determining if the teacher finds value in the use of the technology in their classrooms. Teachers that have a high level of confidence in their own ability and have favorable views of technology to support student learning are more likely to use technology with their students (Ertmer et al., 2012; MacCallum & Jeffrey, 2014).

One-to-One Computing

Inexpensive computing devices such as the Google Chromebook have recently entered the market as an alternative to more expensive laptops or computer laboratories and has been rapidly gaining popularity in many school systems due to their low cost and functionality as a laptop replacement (Molnar, 2014). As a result, many systems are purchasing one device for every student to use at school and often at home (Fleischer, 2017; Kennedy et al., 2016; Zheng et al., 2016). This increased access to technology on a day-to-day basis has been shown to lead to changes in teacher behavior toward technology integration that favors more student-centered learning and utilizing online tools (Varier et al, 2017).

One-to-one computing environments provide many benefits to the teachers and students with studies consistently reporting that students tend to be more motivated and engaged with the learning when they have their own device (Fleischer, 2017; Lindsay, 2016; Roschelle et al., 2004; Varier et al., 2017). In these setting, teachers have also reported increased access to and use of formative assessment applications through online tools (Varier et al, 2017). By improving access to these tools, teachers are more likely to use them more often with their students. When teachers use one-to-one access for formative assessment purposes, strong positive gains in academic performance have been reported (Koedinger et al., 2010; Sheard & Chambers, 2014). Within a one-to-one setting, teachers can use the transformational power of technology to provide quick feedback to students on their learning, which motivates students and increases achievement.

Effects of Computer-Based Feedback

The effectiveness of computer-based feedback derives from the immediacy of the feedback provided to the student on the quality of their responses, which in turn allows the student to make adjustments to their learning (Varier et al., 2017). This feedback can take different forms depending on the application being used and may result in the teacher or another student providing the feedback. The applications will often provide either simple verification of the correctness of an answer or provide more elaborative feedback. Feedback can also be public, with all students getting the correct answer at the same time, or private, with the student getting the information on their own device (Alcoholoda et al., 2016). All of these forms of feedback were found to be more effective than no feedback; however, the form of feedback used will impact the overall effectiveness of the feedback on student learning. Several studies have found that simple feedback is as effective as or more effective than more elaborative feedback due to the fact that some students may not take the time to read through the more elaborative responses (Alcoholoda et al., 2016; Maier et al., 2016; Sheard & Chambers, 2014). In order for feedback to be effective, the student must find it useful and apply the feedback (Maier et al., 2016). Despite these differences in feedback types, the potential for computer-based formative assessment to provide stronger academic gain over paper-and-pencil assessments has been demonstrated (Alcoholoda et al., 2016). With the current level of technology integration in the modern classroom, computer-based formative assessments (CBFA) are promising tools to increase student achievement if teachers choose to use them with enough frequency with their students.

Computer-Based Formative Assessments

The two primary goals of formative assessment are to assess the current level of each individual student, and then provide individualized instruction or feedback based on that data (Black & Wiliam 1998a). One of the first systems used by teachers to utilize CBFA in the classroom was called the Student Response System (SRS), often called clickers (Lee et al., 2012). These early CBFA devices allowed students to use a handheld device to select a multiple choice or true false answer, which was then submitted to the teacher computer. The teacher could then display the correct answer as well as a distribution of answers to the classroom. The need to purchase these specialized devices along with distribution of the devices to classes and students was a limitation of this system. Now, with the emergence of one-to-one computing along with many free-to-use online tools, access to CBFA applications has never been greater. Many of these programs are free while others require a paid subscription. Students can often access these applications from a variety of devices, such as mobile phones, laptops, or tablets (Fuller & Dawson, 2017; Shute & Rahimi, 2017).

As with most online tools, new applications are continually being introduced. It is this ever-changing availability to new applications that provides such an opportunity to teachers to motivate their students yet also challenges teachers and school leaders to remain current with the technology. CBFA can be extremely helpful in a one-to-one setting in facilitating the assessment and feedback process with the ability to quickly assess each student and then to present custom feedback responses, either automatically or from the teacher. The CBFA systems currently available may be able to support the learning goals of teachers and students if teachers choose to use them with enough frequency. These applications, like the clickers, collect student response data and compile the results into charted data that allows teachers to make immediate instructional adjustment as well as provide feedback to students in the form of teacher-led discussion. It is the current CBFA practice of teachers within one school system that this study will be explored further.

Statement of the Problem

With the widespread availability of high-speed internet and WI-FI capabilities in schools, coupled with the development of inexpensive personal computing devices and online educational tools, more and more school districts are choosing to implement one-to-one computer initiatives for the potential benefits of the technology on student achievement. District leaders, mindful of the significant cost to upgrade their existing technology infrastructure to support such a large number of devices, the cost of the devices themselves as well as the support staff to maintain the networks and devices, are certainly interested in maximizing the impact of the devices on student achievement. By potentially increasing formative assessment usage by teachers, CBFA is a promising use of the technology if teachers choose to use it with enough frequency. With the wide range of available CBFA applications and newer applications being added with regular frequency, an up to date analysis of applications that are being used by teachers in their classrooms is needed.

Furthermore, teacher attitudes and beliefs on the benefits of using the technology for this purpose have been shown to strongly influence their decision to use technology. Professional learning and collaborative support are effective means to address barriers to formative assessment practice and instructional technology usage. In order for district leaders to provide appropriate support for such usage, they must understand what applications teachers are utilizing with the devices for this purpose and what factors may be impacting teacher choice to use CBFA in their classroom. By utilizing teacher perception data, school leaders can provide specific and timely professional development activities to support their teachers' acquisition of CBFA practices and skills, which may lead to more motivated students and strong academic gains.

Purpose Statement

The purpose of this correlational study is to investigate the CBFA practices of core academic teachers within a one-to-one computing environment in one mid-sized suburban Georgia school district to better understand the relationships between teacher usage rates of CBFA in their classrooms and their beliefs and attitudes toward technology.

Research Questions

The following overarching and equally weighted research questions will guide this study:

1. Which CBFA applications are middle school and high school academic teachers in one mid-sized, suburban Georgia school district using in a one-to-one networked environment to formatively assess student learning?
2. Are there differences in average CBFA usage rates across teacher and course-specific factors in a one-to-one computing setting?
3. To what degree does teacher comfort with technology correlate to their frequency of use of CBFA in a one-to-one computing setting?
4. To what degree does a teacher's perceived benefit of using instructional technology in the classroom correlate to their frequency of use of CBFA in a one-to-one computing setting?
5. To what degree does teacher perceived technology support and vision correlate to their frequency of use of CBFA in a one-to-one computing setting?
6. To what degree does a teacher's level of perceived autonomy correlate to their frequency of use of CBFA in a one-to-one computing setting?

Significance of the Study

This study is intended to contribute to the growing base of knowledge about one-to-one computing initiatives specific to which CBFA applications teachers are selecting to use with their students and how teacher beliefs and attitudes toward technology are impacting their frequency of CBFA use. With the increasing availability of a wide assortment of web-based formative assessment tools, this study will seek to explore a snapshot of current CBFA applications that teachers are using in their classrooms in one mid-sized suburban Georgia district. A review of the available literature found little evidence of studies that have investigated the CBFA practices of teachers in a one-to-one computer setting or that sought to determine specific factors that may impact a teacher's choice to use CBFA more often with their students. While teacher use of formative assessment is a proven method of increasing student achievement and is now a formal requirement in the new Georgia teacher evaluation system, many teachers continue to struggle with effective and consistent implementation of the practice.

This study explored teacher CBFA usage as well as examined the teacher and class-specific factors that may have a relationship with the frequency of teacher CBFA usage in this one-to-one networked setting. This study is of significance to several groups within the secondary educational setting including district leaders, school-level leaders, and classroom teachers. This study examined formative assessment practices in a district that implemented a one-to-one Google Chromebook program for all students in grades three through twelve. This study will be important to district policy leaders as they determine the direction their school systems will take toward technology integration and plan for implementation of one-to-one programs. Data obtained from this study may be used by school systems considering a technological program investment, to determine how instructional practices may be affected and provide insight into teacher perceived barriers that must be addressed while implementing such a program. Secondly, this study may be impactful to school-level leaders in that the results will identify the variety of ways that teachers in this district are using Google Chromebooks and other technology to formatively assess students using Web 2.0 tools. This information may guide professional development decisions within the school and assist school-level leaders in providing their teachers with additional tools that they can use to effectively monitor and adjust instruction. Finally, many teachers struggle to find ways to formatively assess all of their students and provide adjustments as needed in a timely manner. This study was intended to provide teachers with information on specific CBFA applications that other teachers in the district are using with their students across the various subjects, grades and class levels.

Procedures

This correlational research study investigated the types of CBFA used in six middle schools and three high schools within one mid-sized suburban Georgia school district and explored the variables that correlate to the teacher's frequency of CBFA use in their classrooms as well as differences in CBFA usage rates across several variables. An electronic questionnaire created with Qualtrics was employed to obtain self-reported answers from the study participants. A self-report survey design such as this allows researchers to use a representative sample to quantify variables of interest to a population and then use the results to draw conclusions regarding the population (Creswell, 2014). Potential participants included 414 middle school and high school academic teachers. These teachers were contacted through the use of the school system email distribution lists and were invited to participate in the study. The initial email contained the purpose of the study, the rationale for their invitation to join the study, and a link to the survey instrument. Based on statistical sampling guidelines, a target goal of at least 128 participants was set (Cohen, 1988). This minimum sample size goal resulted in a targeted response rate of 30.9%. Participants were given a two-week window for submission of their responses. After one week, a reminder email was sent to all potential participants and this led to a total of 280 responses. Of these, 261/414 were complete and were able to be used for the study, for a response rate of 63%.

Several variables from the literature review that have been shown to have an influence on teacher use of instructional technology and formative assessment practices were measured and compared in this study. Of primary interest to this study was the number of days in the prior five days that the teacher had chosen to use a CBFA with his/her students during class time. To account for the different levels of classes that the teacher may had been teaching (advanced or gifted, collaborative, or on-level classes), the CBFA usage count question was posed in three separate questions. This resulted in three CBFA usage quantities that were examined separately and as an overall average of CBFA usage for that teacher. This particular self-reported measure was chosen for the ease of the participants to accurately self-quantify his/her CBFA usage over a recent period of time. The instrument also collected data on eight other teacher and class specific questions related to teacher demographic information, class specific information, teacher collaboration and professional learning experience, and a series of Likert-type questions measured the four constructs, *Comfort with Technology* (CWT), *Perceived Benefit in Using Technology* (PBT), *Technology Vision and Support* (TS), *and Teacher Autonomy* (TA). Teachers were also asked to report on which specific CBFA Web 2.0 tools that they had used in the prior 30 days. Finally, teachers were asked to describe why they may have chosen to use CBFA at different rates with their classes at different academic levels, if they reported such a difference.

Using descriptive statistics, ANOVA, and correlations, several variables were investigated related to teacher and course-specific factors as they compare to CBFA usage rates across class levels. To answer research question one, the first part of the data analysis sought to determine which CBFA applications teachers were using to formatively assess their students over the prior 30 days. The researcher compiled a frequency tables to report on the number of study participants that were using specific CBFA applications with their students. The researcher sorted this data by grade level and subject to determine what percentage of participants in each subject and grade level combination was using each of the named applications. Descriptive statistics were used to quantify usage rates for the different subjects and grade levels. To answer research question two, the researcher used ANOVA along with descriptive statistics (Gay & Airasian, 2000; Girden, 1992) to determine if prior research findings related to differences in student-level and class-level technology usage by teachers was also found in this one-to-one setting specific to CBFA usage rates. Prior to using ANOVA, the homogeneity of the variance was tested using Levene's test (Conover et al., 1981). A significance level of .05 was used in this analysis. This analysis was used to determine if there were any differences in mean CBFA usage across eight teacher and course specific factors measured in the study for each of the three different levels of classes taught (advanced/gifted, on-level, or collaborative) as well as the teacher average CBFA usage count for participants of the study. These eight factors included: years of teaching experience; subject taught; grade level taught; professional development in the use of formative assessments; professional development in the instructional technology; collaboration on formative assessment usage; collaboration on instructional technology; and if the teachers were primarily teaching courses with standardized end of course tests. Additionally, the researcher reviewed and coded responses to the open-ended question concerning the reasons why certain teachers may have reported using CBFA at different rates with different academic levels. These data were reported in narrative form and in a summary table by theme. Parts three, four, five, and six of the data analysis utilized Pearson r correlations and descriptive statistics to determine if there were statistically significant relationships among average CBFA usage and CBFA usage at each of the three class levels for the four constructs in the study. Pearson r is used to determine the strength and direction of the correlation between variables that are ratio data or interval data (Gay & Airasian, 2000). Furthermore, according to Gay and Airasian (2000), it is customary in educational research to treat constructed scales, such as the ones measured in this study, as interval data; therefore, it was an appropriate statistical tool for this analysis. An exploratory analysis of individual items within the constructs of teacher-perceived technology support and vision, and perceived autonomy was investigated using descriptive statistics and Pearson's r correlation to determine if any significant relationships existed between those items and CBFA usage rates. The results of the study were organized into tables and in narrative form. Additional information about the methodology will be reviewed in greater detail in chapter three.

Definitions of Key Terms

The following are key terms that will be used in this study that requires a definition in order to understand their significance to the study.

Assessment of Learning – This refers to the assessment that occurs after the instruction is completed to determine how well learning goals were reached. This term also refers to summative assessments (Harlen, 2007).

Assessment for Learning – This refers to assessments that are used to guide instruction. It typically occurs before or during instruction. This term is frequently referred to as formative assessment (Stiggins, 2005).

Chromebook – A portable computing device that has WIFI internet capability which is similar to a laptop without a disk drive or hard drive.

Classroom Response System (CRS) – A system that allows teachers to create questions that are posed to students digitally. Through a response device, often referred to as a clicker, teachers are able to collect statistical data on student responses to the questions.

Computer-Based Formative Assessment (CBFA) – Any use of computer technology to assess learning in order to adjust instruction.

End of Grade Assessment – A state-mandated standardized test that is given at the end of the academic school year for the purpose of measuring academic achievement.

Formative Assessment (FA) – Any use of an assessment to guide or alter instruction (Greenstein, 2010).

First-order Barrier – This refers to external factors that impede the implementation of a change initiative (Ertmer, 1999).

High Stakes Testing – The use of student assessment outcomes to make accountability determinations about students, educators, schools or districts.

Networked classroom – A classroom that has WIFI connectivity where each student and the teacher has their own personal computing device for instructional use (Roschelle et al., 2004).

One-to-One Computing – A learning environment where the ratio of computers to students is 1:1 and students have access to the computer throughout the day and at home.

Second-order Barrier – This refers to internal factors within the control of the subject that impede implementation of a change initiative (Ertmer, 1999).

Self-Assessment – Any assessment that is conducted by the subject for the purpose of assessing their level of understanding of a topic.

Value Added Measure – A measure of teacher effectiveness based on comparing student test score performance to other students of similar testing history (Stronge et al., 2011).

Web 2.0 Tools – Online software programs that allow users to interact with other users in a variety of ways.

Chapter Summary

With the widespread integration of one-to-one technology initiatives and the availability of many free and easy to use CBFA Web 2.0 tools, a close examination of teachers' formative assessment practices in district setting was the focus of this study. In this chapter, a review of the relevant literature was presented that will inform this study. A detailed review of the legislative initiatives was examined. The new teacher evaluation system and accountability measures that have shaped formative assessment policy and the factors that have contributed to the evolution of one-to-one computing policies in Georgia was discussed. This was followed by an examination of the positive academic effects of formative assessment on motivation and achievement and the barriers to implementing these practices. The review continued by examining the literature on the expansion of technology in education, the emergence of interactive web-based assessment tools as well as the barriers, both external and internal, to integrating technology in education. An investigation into one-to-one computing initiatives was explored and detailed the implications of such programs for district leaders, teachers, and students. While many studies have investigated the barriers to teacher use of technology in general, no research was found that has specifically investigated teacher use of CBFA and how different factors may be related to the frequency of CBFA usage by teachers in one-to-one computing settings.

CHAPTER 2

REVIEW OF THE LITERATURE

The following literature review is grounded in the literature stemming from four major areas of specific interest to this study. These include, formative assessment theory, the evolution of instructional technology in education and the barriers that teachers face with implementation of technology in the classroom, one-to-one computing initiatives, and Web 2.0 CBFA applications. First, the literature on formative assessment will be reviewed. This will include a review of the impact on student achievement, barriers to implementing a robust formative assessment practice in the classroom as well as the effect of professional learning and collaboration in overcoming those barriers. Second, the evolution of educational technology will be reviewed and barriers that teachers face when implementing technology into the classroom will be explored. A review of what constitutes first-order barriers to using technology, such as access to computers or reliable WIFI, and how these barriers impact a teacher's instructional decisions will be conducted. The review will continue investigating instructional technology barriers by examining the second-order barriers such as teacher beliefs and teacher self-efficacy with technology and how these barriers shape the teacher's use of technology in their classrooms. Third, a review of computer integration into the educational setting will explore how the progress of one-to-one computer access has evolved to its current state. The benefits and limitations of each of the iterations of this progression will be examined as well as the impact on student motivation and learning. This chapter will continue with a discussion of the relationship between the emerging one-to-one technology initiatives with the widespread availability of an assortment of online educational assessment applications known as Web 2.0 tools. A review of applications that have been studied, their impact on classroom practices, factors that impact a teacher's decision to use these technologies in their classroom as well as the potential for student achievement when paired with formative feedback will be explored. The literature review will conclude with a summary of several other currently available Web 2.0 tools that teachers can use for formative assessment with their students.

Literature Search

The research for this literature review was found by using the university library online electronic databases. The library provided access to the following databases: Educational Research Information Clearinghouse (ERIC), GALILEO, EbscoHost, and ScienceDirect. Additionally, Google Scholar was used to cross-reference additional sources that were found and cited in research. A search of related dissertations was conducted through the online library resources to determine relevant research conducted in the areas of interest to this study. The searches used keywords and phrases such as "formative assessment", "one-to-one computing", "barriers to classroom technology", "assessment for learning", "computer-based assessment", "technology integration", "teacher resistance to change", and "teacher professional development". The researcher limited the original searches to sources published after 2010. Sources that appeared as citations in multiple studies were also included regardless of the year of publication as they were considered landmark studies. Through these searches, additional sources were found as references in peer-review journals, books, articles, and dissertations.

Theoretical Framework

The formative assessment theory of Black & Wiliam (1998a, 1998b) and the instructional technology theory of Ertmer (1999) guided this research study. Each theory provided insights into the benefits and barriers to effective implementation of these practices and informed the purpose and design of this study to explore the use of computer-based formative assessments in middle school and high school academic classes in a Georgia school district that operates in a one-to-one computer to student ratio. Formative assessment theory holds that the learning process is supported when two conditions are met. First, students are given immediate feedback on the quality of their responses to an assessment item and second, the students must use this feedback to adjust their learning processes. The instructional technology theory of Ertmer (1999) holds that teachers face two distinct types of barriers to implementing technology, which will either be external or internal to the teacher. External barriers are referred to as first-order barriers and include such things as access to technology, time to plan for technology usage, and the ability to use technology. Internal barriers are referred to as second-order barriers and include teacher beliefs and attitudes about technology. These barriers to technology usage are of special interest to the purpose of this study as it explored the relationship of first and second-order barriers on the use of computer-based formative assessments.

Formative and Summative Assessment

The idea of formative assessment in education is not a new topic and was based on the work of Michael Scriven concerning specific differences between formative and summative assessments as early as 1966 (Stiggins, 2005). Benjamin Bloom expanded the knowledge base in 1984 with his landmark study of the positive impact of formative assessment on student achievement (Bloom, 1984). Formative assessment is often thought of as an assessment for learning (Stiggins, 2005; Wiliam, 2011), as it typically occurs during the instructional portion of the lesson to inform and guide instruction. The teacher or student performs an informal assessment and uses that information to make a determination about the next instructional step. This process of assessing and adjusting is then repeated often. As stated by Greenstein (2010):

> Formative assessments allow both teachers and students to measure learning by inches,

ounces, and degrees. The results can inform teacher and student decisions about what to do next on an hour-to-hour, day-to-day, or month-to-month basis (p. 3). Additionally, formative assessments are often considered low-stakes in that assessment results are generally not taken for a grade (Dixson & Worrell, 2016). This approach allows students to take the assessment without the pressure of a more formal summative assessment.

Summative assessment, or the assessment of learning (Harlen, 2012), on the other hand generally occurs at the conclusion of a learning unit to assess the degree to which the subject learned the material. It simply measures the current student level of achievement on the given learning objective (Cauley & McMillan, 2010). It must be noted, that it is not when the assessment is given, rather it is the purpose of the assessment and if an adjustment to instruction occurs as a result, that determines if an assessment would be considered formative or summative in nature (Harlen, 2012). A summative assessment could be formative in nature if the results were used to inform and alter the instructional plan after the assessment. An over-reliance on summative assessments has been reported to negatively impact the quality of formative assessment practices (Black & Wiliam, 1998b; Box et al., 2015; De Lisle, 2016).

The Effectiveness of Formative Assessment

A large body of research has shown the positive educational benefits of formative assessment on student achievement and motivation (Andersson & Palm, 2017; Black & Wiliam, 1998a, 1998b; Bloom, 1984; Cauley & McMillan, 2010; Meusen-Beekman et al., 2016; Stiggins, 2005). In a seminal study, Bloom (1984) stated that when formative assessment is used with fidelity in a classroom with about 30 students under ideal situations, the results will generally be a measurable improvement of about one standard deviation from the mean, or as stated by an effect size of 1-sigma. Black and Wiliam (1998a) found similar results with an average effect size of around 0.7-sigma in the quantitative studies that they examined. They reported that if these results could be achieved nationally, it would advance the achievement scores of the United States to some of the highest in the world. While these effect sizes are substantial, the ideal formative assessment setting was found to occur when the teacher-to-student ratios was reduced to a tutoring setting of one-to-one. Under these circumstances, the effect size jumped to a substantial two-sigma, or two standard deviations from the mean (Bloom, 1984). While schools could not afford a one-to-one teacher-to-student ratio, attempts to find an instructional approach that gives a similar effect size with normal class sizes would become paramount. As far back as 1984, Bloom mentioned computer-based learning as being an effective tool when used with motivated students and suggested that better computer applications in the future may be able to replicate the same effect on achievement as one-to-one tutoring.

Barriers to Formative Assessment Practices

Despite the evidence of the effectiveness of formative assessment to increase student achievement, research has indicated that the use of effective formative assessment techniques by teachers to guide instructional decisions in the classroom is not occurring at consistent or significant levels in many classrooms (Andersson & Palm, 2017; Cotton, 2017; De Lisle, 2016). There exist certain prerequisites that must be in place in order to support teachers' use of formative assessments, which should include professional learning on formative assessment usage. Other barriers to formative assessment usage include the teachers' own personal beliefs and assumptions about instruction, student ability, and time to cover the curriculum (Box et al., 2015; Ertmer et al., 2012; Powell & Kusuma-Powell, 2015).

Professional Learning

Several studies investigated the use of professional learning to overcome barriers to implementing a formative assessment program (Andersson & Palm, 2017; Box et al., 2015; Hollingworth, 2012; Koloi-Keaikitse, 2016). These studies indicated that purposeful professional development was an essential component of changing teacher practice related to formative assessment. In a recent quantitative study, Andersson and Palm (2017) conducted research in a school district in Sweden to determine if teachers that are given professional learning on using formative assessment techniques will use the formative assessment practices in their classrooms. They also sought to determine if this change in practice derived from the professional learning would have an effect on student mathematics achievement. As a result of the professional learning provided to the teachers in the study, the primary change in teacher behavior came from teachers using a variety of student response systems and providing more feedback in the form of comments and not grades. The most commonly reported response systems used were mini-whiteboards and exit passes. Using a control group and an experimental group the researchers conducted a statistical analysis to determine the effect this change in assessment practices would have on student achievement. The results indicated that the students in the classrooms with teachers that received professional development scored significantly higher on the post-test after adjusting for the pre-test scores resulting in significant differences in mathematics achievement between the students in the groups. This suggests that professional learning can enhance classroom practice of formative assessment usage and lead to greater academic gains.

In a quantitative study, Koloi-Keaikitse (2016) used a questionnaire to determine how assessment training levels predicted the frequency of use of several types of assessment practices in the classroom. A total of 691 primary, junior, and senior secondary level teachers from eight educational regions of Botswana participated in this study. The questionnaire was developed from an existing instrument used in the United States and measured various types of professional development activities that each teacher had participated in related to assessment and it also measured their frequency of use of six types of assessment practices. These practices were criterion referenced testing, grading practices, statistical application, assessment application, essay items, and objective items. Researchers used regression analysis to predict how the teacher's level of assessment training impacted the frequency of use of each assessment practice. Results indicated that teachers that had participated in in-service workshop training specific to assessment usage were more likely to use assessment practices in their classrooms than those that had not. The researcher also found that learning about assessment in a college course covering other topics or taking a dedicated college course in assessment added minimal value in increasing assessment usage and did not add to the frequency of assessment usage by the teachers. These results demonstrate that dedicated in-service training on specific assessment practices relevant to the teachers' practice are needed in order to influence the use of formative assessment in their classroom.

Teacher Beliefs

In several studies, teacher belief and understanding about formative assessments have been shown to impact actual classroom implementation of formative assessment practice (Box et al., 2015; Cotton, 2017; Lee et al., 2012; Missett et al., 2014). A teacher’s personal belief in the efficacy and proper ways to use formative assessments will influence his/her formative assessment practice (Missett et al., 2014). Often these beliefs will lead teachers to use formative assessments in ways that are not aligned to formative assessment best practices such as using formative assessment for grading purposes rather than for learning and instruction (Black &

Wiliam, 1998a; Dixson & Worrell, 2016; Havnes et al., 2012; Wiliam, 2011). Teachers rarely use formative assessments in a purely formative manner and most often assign a grade to assessments (Havnes et al., 2012). In 2015, Box et al. conducted a qualitative case study to determine how teacher personal beliefs, values, and knowledge, constrained or facilitated a teacher's use of formative assessments in their classroom. Three biology teachers from a high school in Texas were chosen to participate in the study, which followed them through a unit on cells. Researchers used classroom observations and detailed feedback interviews after observations to collect data from the teachers on their formative assessment practice and beliefs. Teacher content knowledge was also central to the teacher's use of rich formative assessments as was the autonomy that the teachers felt from their leadership in trying new things in their classrooms. Teachers that did not have a rich content knowledge to draw from were limited in their feedback and follow up to discussion questions, which impacted the quality of the feedback. It was also noted that the teachers' expectation of student ability significantly affected the use of formative assessments. The researchers found that teachers used formative assessment less often in lower level classes. Lastly, the factor that most significantly hindered the use of formative assessment by the teachers in this study was that all three of the teachers felt that there was not enough time to use formative assessments because there was too much curriculum to cover and thus they felt the need to teach to the end of course test (Box et al., 2015, p. 973). This study is limited by the number of teachers used in the study, the same subject was taught by all three and that they all came from the same school. The findings may not extend to other schools, subjects or teachers. While this study found that teacher beliefs and attitudes within this school significantly impacted their formative assessment practice, the study did not compare how teacher beliefs from several schools with different leadership styles may impact their use of formative assessments, nor did it investigate the possible differences in formative assessment usage rates among teachers that have an end of course test, and those that do not. The current study seeks to fill this gap in the research.

Leadership and Culture

Another critical component found in schools where teachers are using high-quality formative assessment is the level of support and autonomy that the teachers experience from school leadership (Birenbaum et al., 2011, De Lisle, 2016; Hollingworth, 2012). Support from the principal in establishing professional learning communities (PLCs), creating time for teachers to collaborate, and providing money to support new curriculum and training has all been found to be instrumental in the implementation of formative assessment practices within a school (Hollingworth, 2012).

Teacher autonomy within a school has been shown to affect the formative assessment practices of teachers as teachers that work in schools that provide a higher level of autonomy have been shown to demonstrate higher quality formative assessment practices than those that work in more top-down regulated structures (Birenbaum et al., 2011). In their qualitative study, the researchers interviewed six elementary school teachers at six different schools in Israel to better understand their assessment practices. Information about the context of the classroom assessment practices used by each teacher was obtained through a focus group of students consisting of two to six students from each of the six teacher’s classes each for a total of 22 students. Additionally, another teacher at each of the six schools was interviewed and served as a source of information about the school leadership and PLCs at each school. Data collected from the interviews were coded and assessed the quality of the formative assessment practices and teacher beliefs related to autonomy and formative assessment. Researchers found that teachers working in schools that are under pressure by leadership to improve test scores and using a centralized leadership approach generally had lower quality formative assessment practices and less collaboration between teachers. This study was limited by the number of teachers that were used in the study as they represented a small sample and may not represent a general understanding of the role of leadership in supporting formative assessment practices and collaborative culture. The qualitative nature of this study also prevents the ability to quantifiably correlate the relationships between formative assessment practice, leadership support, and teacher collaboration. The current study seeks to close this gap in the literature.

Technology in Education

The use of educational technology in the 1900s progressed at a steady rate with the addition of such items as the film projector, radio, overhead projectors, calculators and eventually personal computers in the late 1970s along with the birth of the internet in the 1980s. It was during this time that the transformational power of computers in the hands of students was being conceived (Parson, 2017). A review of policy documents from this time indicated that as early as 1992, policymakers were already outlining how the use of computers could enhance and streamline assessment practices (Culp et al., 2005).

Recently, with the availability of the internet in nearly all classrooms in the United States, along with inexpensive personal computing devices, students' access to interactive technology has never been greater (Wells & Lewis, 2006). More recently, an increasing number of schools and districts have implemented one-to-one computer-to-student ratios which assign a portable computing device to each student, many of which allow the students to take them home (Singer, 2017). Additionally, a range of interactive Web 2.0 educational applications are widely available for teachers and students to use within the classroom and from home (Bower, 2016). Many of these applications provide teachers with the time-saving ability to collect and analyze data within the program in real time (Fuller & Dawson, 2017; Iwamoto et al., 2017; Wash, 2014). Despite the rapid increase in the use of one-to-one devices in classrooms in recent years and the immense opportunity for educational application and improvement, few research studies have been conducted to document the effect this has had on specific instructional practices such as the frequency of formative assessment usage in the classroom.

First-Order Barriers to Technology

Schools and districts have had to overcome many external or first-order barriers to provide computer access to students. These first-order barriers included such things as access to the internet, the cost of the rapidly outdated computers, space and time for their use, professional learning support for teachers, and student technological abilities (Blackwell et al., 2014; Ertmer, 1999; Hew & Brush, 2006; Tas, 2017). The pace of technology integration in American schools has risen substantially over the past 20 years, going from 8% of schools having internet access in 1995 to 98% in 2008, and the ratio of personal computers to students in schools fell from 6.6 to 1 in 2000 to 3.1 to 1 in 2008 (National Center for Education Statistics, 2010). While many of these first-order barriers have been largely reduced, there still exists the need to consider the effects of these barriers on teacher attitude and usage of technology in the classroom.

While access to computing devices will vary from district to district, with the recent development of inexpensive personal computing devices, such as the Google Chromebook, the level of student access to computing and the internet has increased (Singer, 2017). Despite the elimination of many well documented first-order barriers (Ertmer, 1999; Hew & Brush, 2006), teachers continually report that they do not have the time, resources, and training to use technology for instructional purposes (Ertmer et al., 2012; Hsu, 2016; Kopcha, 2012).

Additionally, student computer skills have been reported as having an impact on technology integration (Hsu, 2016); however it appears that when teachers have a very high level of self-efficacy toward computer integration, this barrier ceases to exist (Ertmer et al., 2012).

Professional Learning and Collaborative Support

Several studies have established that professional learning and collaborative support are important factors in overcoming barriers to technology integration (Blackwell et al., 2014; Ertmer et al., 2012; Heath, 2017; Hew & Brush, 2006; Hsu, 2016; Karatas et al., 2017; Kopcha, 2012). Despite this, research conducted by Hsu (2016), found that less than half of the 152 teachers in their study reported that they had participated in any professional development specific to technology integration. To expand on the understanding of professional learning on instructional technology usage by teachers, Kopcha (2012) conducted a two-year longitudinal mixed-methods single case study to examine the effects of a situated professional development on evolving teacher beliefs and practices to common barriers to integrating technology into the classrooms. These barriers included access to technology, a vision for technology use, teacher professional development, time to learn new technology, and teacher beliefs related to technology efficacy. The subjects of the study were 18 elementary school teachers and 600 students in a Southwestern city in the United States that was just beginning a major upgrade to their technology infrastructure. This included a laboratory with 32 new computers and an interactive whiteboard, five mobile carts with 15 wireless laptops each, and online computer-based instruction available to all students. During year one of this upgrade, the district provided a technology mentor to work exclusively with the teachers to provide them with the skills and knowledge that they would need to integrate the technology into their instructional practice. This consisted of in-class coaching, support, modeling, and observations. At the conclusion of year one, the researchers collected survey data to establish a baseline on teacher beliefs and practices.

During year two, the mentor transitioned the teachers to PLCs in an effort to continue supporting the technology needs of the teachers. At the conclusion of the two year period the researchers administered a survey and conducted interviews to determine if beliefs or practices had been affected by the transition to PLCs from the mentor. The results of interviews and quantitative analysis indicated that teachers consistently reported that they felt the time to integrate the technology was a negative factor. The researcher also found that the teacher's beliefs concerning the benefit of the technology to improve student learning increased after working with the mentor. They also found that teachers reported that it was harder for them to find the time to locate and use the technology resources without the mentor's help. The overall results indicated that the PLCs were able to sustain the teacher's positive beliefs about the use of the technology integration; however, it was not able to support the teacher's professional learning without the mentor. This suggests that in-classroom professional development may be better at overcoming technology implementation barriers related to time and professional knowledge than PLCs or other professional learning that occurs outside the classroom. This study was limited by the small number of teacher participants in a single school and did not address other potential causes for the teacher beliefs expressed in the study. The current study will seek to close this gap in the research.

In another study, Ruggiero and Mong (2015) conducted a mixed-methods study in a Midwestern state in the United States to determine what technology tools teachers were using in their classrooms and how they learned about these tools. In this study, the term "technology tools" was not pre-defined for the participants; however the researchers did apply a loosely constructed definition as they compiled the responses given by the participants (p. 166). The sample included 1048 teachers across all disciplines. A survey instrument was created to collect self-reported answers to demographic questions from each teacher and then they were presented with two open-ended questions related to technology tools. The first question asked what technology tools the teacher used in their classroom. The second question asked the teacher to identify how they learned about technology tools. Follow up interviews were conducted individually with 111 of these teachers to confirm themes found during the survey portion of the study. Results indicated that technology usage was pervasive among all levels. The most commonly reported use of technology tools was PowerPoint, film or video, and games. The least used tools were virtual field trips, online discussions, and Web 2.0 technologies. The study also found that types of technology used varied between elementary and high school. Elementary was much more likely to use interactive tools compared to high school which used more presentation tools. The study also found that most teachers reported training as the way they learned about new technology tools. This training came in the form of workshops, conferences, or from other teachers. This study is significant to research on computer-based formative assessment, as it discussed the implication of teacher choice in selecting technologies to use with their students as well as the importance of professional learning and collaboration. While the availability of one-to-one technology was not mentioned in the study, it can be surmised that many of these schools would not have had a one-to-one computer ratio. This may have impacted the technology tool uses that teachers reported and may explain the low level of Web 2.0 application usage reported.

In their quantitative survey study, Karatas et al. (2017) were interested in determining if there were differences in technological pedagogical content knowledge (TPACK) perceptions for pre-service middle school mathematics teachers related to gender and their college grade-level.

The subjects in this study were pre-service middle school mathematics teachers, which ranged from freshmen to seniors in undergraduate programs from several universities across Turkey. In total 427 pre-service mathematics teachers participated in the study. The researchers utilized three survey instruments to measure TPACK, these measured content knowledge, self-confidence, and technology usefulness perceptions. Each instrument was developed from prior validated instruments. One-way between-groups multivariate analysis of variance was used to compare means of the constructs for gender and college grade-level. There was a statistically significant difference between male and female pre-service middle-grades mathematics student content knowledge, self-confidence, and perception of using technology in mathematics instruction. Specifically, males had higher levels of content knowledge and self-confidence with technology, while females had a higher rating on their perception of technology usage. These results suggested that while male students feel more confident and have more technology knowledge, while female students see more value in using technology with students. Additionally, seniors were shown to have higher levels of technology content knowledge, self-confidence to use technology, and positive perceptions of the usefulness of technology than the other grade levels. As the seniors in the study had all taken additional coursework specific to technology integration, this suggested that these TPACK constructs all improved through learning about new instructional technology and having more experience using technology. This study supports other research that indicated that through training and hands-on use, teacher confidence and positive perception of technology is improved (Blackwell et al., 2014; Ertmer et al., 2012; Heath, 2017; Hew & Brush, 2006; Hsu, 2016; Kopcha, 2012). The results also suggested that the technology professional development for males and females may need to address different needs. While this study investigated pre-service teachers and their perceptions of instructional technology, this current study will extend this research to examine in-service teacher perceptions and how they are related specifically to their actual instructional technology usage as it relates to formative assessment.

Teaching Experience

Three studies were found that reported differences in teacher beliefs about first-order technology integration barriers and their number of years of teaching experience (Blackwell et al., 2014; Hsu, 2016; Semerci & Aydin: 2018). Using a mixed-method approach, Hsu (2016) administered a 22-question open-ended survey to 152 elementary school teachers that taught in urban, rural, and suburban school districts near Chicago. The purpose of the study was to examine beliefs, practices, and barriers to technology integration in these districts. The researcher categorized teachers by the level of teaching experience, teachers with 1-3 years of experience and those with more than three years of teaching experience. Of the 152 participants in the study, 20% had between one and three years of teaching experience and 80% had more than three years of teaching experience. The researcher coded the responses to the teacher reported perceived barriers as one of four established barriers to technology integration and included: teacher lack of time to integrate technology, teacher lack of technical support, teacher lack of training and exposure to technology, and students' lack of computer skills. Results indicated that 25% of the less experienced teachers reported that teachers' lack of training was a barrier, while 75% of more experienced teachers reported this as a barrier. The lack of technical support was reported as a barrier by 40% of the less experienced teachers compared to 60% of the more experience teachers. The lack of computer skills was reported as a barrier equally by approximately 50% of both groups. Finally, 20% of the less experienced teachers reported that a lack of time to implement technology was a barrier, compared to 80% of more experienced teachers. This research implies that teachers with less teaching experience are more comfortable with technology and may require less support and professional learning.

Similarly, Blackwell et al. (2014) found in their study of 1234 early childhood teachers that the teachers with more teaching experience had less positive attitudes toward technology integration. However they went on to report that the more experienced teachers tended to use the technology more often with their students. This suggests that while newer teachers may be comfortable using technology themselves, they may have less experience incorporating it into an educational setting due to a lack of pedagogical knowledge and skill.

In another quantitative study, Semerci and Aydin (2018) used a non-experimental survey design to explore the attitudes toward educational technology integration of high school teachers in Turkey. Researchers examined if teacher use instructional technology attitudes differed by gender, age, teaching experience, instructional technology (IT) experience, skills, or training. A total of 353 high school teachers from several public schools in four districts participated in the study. Teacher attitude toward instructional technology was measured by a prior validated scale that consisted of two factors. One factor measured teacher willingness to use instructional technology, while the other factor measured teacher anxiety toward instructional technology. Researchers used independent samples t-tests and one-way ANOVA to compare mean differences across groups. Results indicated that there were no significant differences in teacher anxiety or willingness to use IT for teachers that had different levels of teaching experience; however, there were significant differences for IT anxiety between teachers with different amounts of IT training, and of different years of experience using IT. Researchers found that teachers with no prior IT training or had less experience using IT with students were significantly more anxious to use IT with their students than teachers with more training or more experience. This research supports prior research that has found a relationship between teacher anxiety to use of technology and their level of training and years of experience using IT. Furthermore, while no significant difference in anxiety toward technology based on years of teaching experience were found, they did determine a relationship between teaching experience with IT and actual technology usage. While this study adds to the growing literature based on how teacher anxiety toward technology can be reduced by training and experience using IT, it did not address how anxiety about technology relates to the frequency of classroom use of technology.

Student Barriers

Several studies have examined the role that the student plays in supporting or hindering the teachers' choice to integrate technology into the classroom (Ertmer et al., 2012; Heath, 2017; Tas, 2017). The level of student computer skills as perceived by the teacher has been found to be a barrier to implementing technology (Heath, 2017; Hsu, 2016). This barrier seems to disappear however when the teacher has a high level of self-efficacy with technology (Ertmer et al., 2012). This research supports the notion that by increasing teacher self-efficacy with technology, the students' efficacy with the technology will increase as well. As professional development has been established as a mechanism to increase teacher self-efficacy, this suggested the critical importance of a quality professional learning program directed at technology integration in increasing technology usage in classrooms.

Tas (2017) conducted a quantitative study to examine the effects on student behavior and motivation in technology-supported classrooms as compared to classrooms that did not support technology. A four-point Likert-type scale survey instrument was used to collect information about classroom management issues. A total of 79 students completed a questionnaire for the data analysis in this study. The measuring instrument was applied to 38 classrooms where technology was not used and 41 classes where technology was used. Independent samples t-tests were used to look for significant differences in the two types of classrooms related to classroom management issues. Results indicated that teachers in technology-supported classes can motivate students, attract students' attention toward the course more easily, and that students were more willing to perform the assigned tasks, than in traditional settings. Interestingly, there was no significant difference between the groups related to the number of off-task behaviors, such as students talking without permission, showing aggressive behaviors toward each other, and disturbing friends during the course. The implication of this research is that while the students are more motivated to learn when teachers use technology, the students' off-task behavior may not be reduced. This can possibly add to the barriers that teachers face when using technology in their classroom, especially if the teacher does not have a high level of technology self-efficacy or an effective classroom management style. This study gives insight into the reported differences in classroom management issues between classrooms that are technology-supported and those that are not, and found that students are more motivated to learn and focus on the assigned task when using technology. This study did not determine if teachers are adjusting their use of instructional technology due to their personal belief in the benefit of the technology on student learning, motivation, and potential for disruptions to the class. The current study will attempt to close this gap in the research.

Second-Order Barriers to Technology

Despite the current level of technology access in the classroom and reduction in first-order barriers, the use of instructional technology still faces certain barriers within the classroom stemming from the internal beliefs of the teacher (Kopcha, 2012). These barriers are now generally not from lack of resources or technical support, but rather are primarily derived from the teacher's internal pedagogical beliefs, assumptions about technology in education, and their self-efficacy with technology. These second-order barriers must be addressed in order to maximize the transformational benefit of technology as an instructional tool (Ertmer, 1999; Ertmer et al., 2012; Hew & Brush, 2006; Minshew & Andersson, 2015). Ertmer et al. (2012) noted that these second-order barriers included teacher fear of the technology, lack of knowledge about the technology, and uncertainty about the effectiveness of the technology to ensure favorable learning outcomes, especially on standardized tests. In order to overcome these concerns, the following elements were found to have a positive impact: establishing a common technology vision, collaborating with other teachers as well as students on ways to integrate technology, and providing ongoing professional development using the same technology tools that teachers are expected to use (Ertmer et al., 2012; Heath, 2017; Hew & Brush, 2006; Kopcha, 2012).

Teacher Beliefs and Classroom Practice

Research on the beliefs that teachers have about technology has been shown to be the true gatekeeper to technology integration by teachers (Hew & Brush, 2006). These beliefs are the lenses through which teachers see the value of technology and the place it has in supporting the learning of their students. It is therefore important to understand how these beliefs affect the choices that teachers make for their students. Other findings have reported that when teachers have a positive belief about technology that they are more likely to work through first-order barriers in order to use technology in their classroom even if these barriers present considerable obstacles (Heath, 2017). When teachers believe in the value of technology to enhance student learning, they remain very motivated to continue to use technology, even when they experienced the first-order barriers of time to plan and learn, and overcome technological issues (Kopcha, 2012). The implication is that teachers that view technology as adding educational value to their classrooms will find a way to use the technology with their students despite the first-order and second-order barriers that may be present. Adding to this understanding, Blackwell et al. (2014) found that the socio-economic status (SES) of the students that a teacher has in their classroom has been shown to have a positive relationship with respect to the frequency of technology usage by the teacher. It is believed that the teachers who view technology positively make conscious decisions to use technology more often with lower SES students that may not have technology access from home.

In another study, MacCallum and Jeffrey (2014) sought to confirm prior research related to factors that influence a lecturer's intended use of mobile technology in their classroom. These factors include perceived usefulness of the technology, teacher comfort with technology, teacher technology literacy, and teacher ability to use instructional technology. The participants of this quantitative study were 175 college lecturers, selected by convenience sampling methods. An online questionnaire was used to collect responses to items related to each of the four constructs. A correlation analysis was performed to identify significant relationships among the variables being studied and the lecturer's reported intention to use mobile technology in their classes in the future. Results confirmed existing relationships among the variables found in general technology usage. Specifically, perceived usefulness of technology appeared to have the most influence on the intended use of mobile technology. Ease of use of mobile technology was not a significant factor for the intended use; however, it was related to teacher ability and comfort with technology in general. This study confirmed the importance of teacher ability and attitudes in the acceptance of mobile technology in their classrooms. These finding will be of significance to the current study in that these factors will be investigated in the unique setting of one-to-one computing related to CBFA usage in secondary classrooms. An understanding of the implications of teacher beliefs, ability, and intended use of technology in the classroom will be explored and will expand the understanding of this research.

In their qualitative study, Minshew and Andersson (2015) sought to determine what factors, both internal and external, impacted the use of iPads in a one-to-one setting for two middle school teachers on the same team at the same middle school in an urban school district in the United States. Researchers also sought to determine how the teacher's perceptions of their technology use compared to classroom practice. For this study, researchers used interviews, classroom observations, lesson plans, and a technology influence diagram to answer the research questions. Results of the study indicated that both teachers faced several external as well as internal barriers to integrating iPads into their instructional practice and they also found that their perception of their own technology use did not always match their actual classroom practice. The external barriers found in the study included connectivity issues, a lack of autonomy in selecting and using applications, and professional development that did not provide them with specific knowledge on applications. Internal barriers included teacher knowledge of applications, perceptions about the usefulness of technology, and teacher perceptions about how they are using technology versus their actual practice. This study highlights the importance of not only eliminating external barriers such as ease of access to technology but also identified how teacher knowledge and perception play a critical role in the implementation of technology in the classroom. A strong professional development plan specific to hands-on training with subject-specific applications is vital. Finally, this study was also significant in that it found that teacher intention to use technology does not necessarily translate into classroom practice. Once again, a more hands-on, in-class professional development program may help overcome this barrier.

In their mixed methods study, Sadaf et al. (2016) sought to determine what factors predicted pre-service teachers' use of Web 2.0 tools with their students. They explored the extent that these intentions translated into classroom practice and what factors influenced their use of these tools. The population for this study was 245 pre-service education majors from a large Midwestern university that were enrolled in a course that conducted a five-week project on Web 2.0 tools. Of these students, 189 completed an online survey that measured attitudes and perception about technology. Follow up interviews were conducted with 12 of these student to further examine perceptions of Web 2.0 tools. Phase two consisted of an exploration of the types of Web 2.0 tools that they were using in their classrooms. A total of 22 students from phase one that were completing their student teaching the following semester were included in this second phase. Of these participants, 14 completed surveys and six conducted phone interviews. Results indicated that pre service teacher's intentions to use Web 2.0 tools in a specific way did not always align with their actual practice for a variety of reasons. These included a lack of access to technology as well as a lack of mentor teacher support. The teacher's positive attitude of perceived usefulness that the technology would improve student learning and engagement was the strongest indicator of intention to use Web 2.0 tools in the classroom. Teacher belief concerning student expectations of technology use as well as teacher technology self-efficacy was also noted as factors that affected intentions to use Web 2.0 tools. The most utilized Web 2.0 tools reported was video editing and sharing tools. Other factors that influenced the use of Web 2.0 tools included mentor teacher support and teacher technology self-efficacy. The current research study will expand on this research by investigating the specific use of Web 2.0 tools for formative assessment purposes, specifically CBFA.

Hsu (2016) found that teachers who had constructivist pedagogical beliefs had much higher self-efficacy and positive beliefs related to technology integration than the teachers with teacher-centered pedagogical beliefs. This may imply that when teachers view themselves as facilitators of students' construction of their knowledge through support and using engaging activities, they are more likely to use technology in their classrooms. The researcher also reported that the subject taught by the teacher seems to impact the use of technology as well. The study found that the teachers were much more likely to use technology during English instruction to support student learning (90% of the time), followed by social studies (50%), science (30%), and then mathematics (20%). In this study, however, technology use was broadly defined as any activity that the teacher or student engaged in that involved: television, overhead projectors, websites, desktop computer applications, laptops, tablets, or iPads. Based on these criteria for inclusion, technology usage was maximized during English instruction as the teachers often used the technology for reading, writing, and grammar. A more narrow focus on using technology to assist in formatively assessing student learning may indicate a different pattern of use across subjects. This is a gap in the research that the current study will attempt to fill.

Ertmer et al. (2012) found that when teachers have a high level of self-confidence with instructional technology integration that their classroom practices will reflect their beliefs. In their qualitative study, they investigated classroom practices of a group of teachers that demonstrated a high level of strength with instructional technology integration. The researchers sought to determine how well teachers' pedagogical beliefs about instructional technology and their implementation of instructional technology practices aligned. The researchers used websites to search for technology award-winning teachers to include in their study. Teachers that had an online presence were screened to determine if their classroom practice reflected a student-centered practice. After screening and sending invitations to join the study, a total of 12 teachers were selected. Individual interviews were conducted via Skype or on the telephone with all teachers. A 4-point Likert-type scale was used to determine how these teachers rated the impact level that several barriers had on technology integration. A rating of 1 indicated no barrier at all, and a rating of 4 was very much a barrier. Results of the interview revealed that these teachers rated their own beliefs about technology as a 1, while they rated the beliefs of other teachers at their school a 3.17. This supports the finding from Hsu (2016) and Kopcha (2012), that teachers with a high level of self-efficacy and who finds value in technology in education will have classroom practices that align very well with their beliefs. This study was limited in that only teachers that were recognized as award-winning technology users were selected to be in the study. Additionally, the evidence of classroom practice came solely from the teachers' websites, and it fails to establish the frequency in which they use technology in their classrooms for specific uses. The current study will attempt to close this gap.

One-to-One Computing

One-to-one networked computing refers to each student in a classroom or school having their own internet connected device to use for educational purposes (Varier et al, 2017). In this setting, many of the barriers to technology access have been eliminated, potentially resulting in increased use by the classroom teacher. As previously stated, teacher beliefs about the benefits of technology in the classroom will greatly affect the extent to which teachers and students use the devices and for what purpose (Heath, 2017; Keane, 2012). In classes where teachers are using these devices, several studies indicated that students working in networked classrooms are more motivated and engaged in the learning process (Fleischer, 2017; Lindsay, 2016; Roschelle et al., 2004; Varier et al., 2017). While these studies have shown that students have increased levels of motivation and engagement, there is limited evidence that simply having access to one-to-one computing will correlate with increased academic achievement. As Kennedy et al. (2016) stated, "previous research on one-to-one laptop initiatives has not been able to provide much useful information on the efficacy of this expensive investment" (p. 157). In their quantitative study, they found only modest academic gains occurred from the use of one-to-one online learning (Kennedy et al., 2016). However other researchers have found that when the technology is used specifically for online formative assessment linked with teacher feedback, strong positive gains were reported, especially for students with learning disabilities (Koedinger et al., 2010; Sheard & Chambers, 2014). While this study demonstrated that in a one-to-one computing setting, the use of CBFA has shown to have a positive effect on student learning in general and a strong positive effect on student learning for students with disabilities, it did not address the teacher's frequency of use of CBFA with students and did not determine if teachers make different instructional technology choices with respect to CBFA usage among classes of students that have different ability levels. The current study will attempt to close this gap in the research.

In a study on a one-to-one iPod Touch initiative, Keane (2012) conducted a qualitative analysis to investigate the ways in which teachers and students in a middle school utilized the devices in the classroom when the students had daily access to their own device. The study sought to determine what problems or advantages were presented with the ease of access to the technology. The study was conducted during a four-month implementation phase where teachers were encouraged, but not required to use the devices in their classrooms. Classroom observations were conducted in several academic subjects across grades six through eight. Interviews were conducted with sample focus groups of teachers and another group of students to determine how the iPod's were being used. Findings highlighted that the level and type of iPod touch usage was very dependent on the individual teacher. One reason noted was that the teachers' level of confidence with the technology shaped how the iPods were being utilized in the classroom. Specific academic subjects were also found to generally use the devices in different ways. Mathematics teachers were noted to have been the least likely to be using the technology, due to limited availability of resources and practical concerns related to the ability of the device to present the subject matter. Another important finding was that students themselves reported an increase in off task behavior from other students misusing the devices. Finally, the limitation of the device itself was noted as being a barrier to use because of the small screen and the need to scroll to see everything on web formatted pages. The commonly reported uses of the devices were formative assessment, remediation, and research.

From this study a few things were of specific interest to the current study. The research setting was a new one-to-one technology initiative in which the teachers were not required to use the devices. Thus the factors of teacher beliefs and autonomy played a key role in shaping instructional uses of the technology. Whereas this study investigated iPod's with no keyboard and small screens, the current research study will look at more capable devices and will investigate the quantity of usage specific to CBFA. General technology use is often examined at the implementation stage of the one-to-one initiative; however, the proposed study will investigate a district that will be going into year four of implementation and will focus specifically on formative assessment usage.

The Potential of One-to-One Devices

Many school districts are moving away from the traditional computer laboratory arrangement in favor of one-to-one computing devices for the increased student access to the technology (Varier et al, 2017; Zheng et al., 2016). Often, districts have multiple options when selecting a computing device for students and each option has limitations and benefits that must be considered in the context of the specific needs of the school and student population. Varier et al. (2017) conducted a qualitative study to investigate how teachers in a large mid-Atlantic school district in the United States integrated various one-to-one devices into their instructional practice, explored the limitations of each device, and examined how the devices impacted student motivation and engagement. The study was conducted over a period of three months to determine the device the district would purchase for district-wide use as part of their multi-year technology improvement plan. A class set of each different device was distributed to specific teachers at each school level, elementary, middle, and high resulting in 18 classrooms at 15 different schools taking part in the study. Data collection consisted of teacher interviews as well as daily reflections of their teaching and student interviews. An analysis of the data collected revealed that regardless of the device being used, there were initial start-up issues that needed to be resolved. Teachers reported that for the first several class sessions, technical issues prevented them from using the devices for the intended lessons; however, these issues were resolved with assistance from technical support.

Of specific interest to the current study, researchers noted a change in instructional practices after the devices were introduced. They noted a change to a more student-centered teaching style occurred and student participants commented on the ability to receive immediate feedback from the teachers as well as other students specifically through online tools. Teachers reported that they had an increased ability to use formative assessments due to the ease of accessing data and providing feedback and also commented on the increased engagement and motivation of the students and felt that even students that typically had not completed assignments were doing so with the devices. The researchers noted that the novelty of the devices was mentioned as a possible explanation and that a longer study could explore this further; however, these results are consistent with other research on the motivational effects of technology (Ertmer et al., 2012; Tas, 2017; Varier et al., 2017). Finally, regardless of which device they were using, teachers strongly recommended that the district move to one-to-one computing. A few limitations to this study need to be mentioned. In this study, the teacher participants were hand selected based on their technology interest and ability. Thus the results may not extend to a broader implementation with teachers that have less experience or comfort with technology. Additionally, the short duration of the study introduces the possibility that the motivational factors noted could be due to the novelty of the devices and may not be sustained over a period of time. These are gaps that the current study will attempt to close.

Effects of One-to-One Laptops on Achievement

In order to extend the understanding of the effects of one-to-one laptop programs, Zheng et al. (2016), conducted the first of its kind meta-analysis on ten one-to-one laptop studies that measured the academic impact of these programs on student achievement. Each of the ten studies contained multiple effect sizes that were computed. The researchers converted the multiple effect sizes from each of the studies into Cohen's *d* in order to have a single statistical measure to compare effect sizes across the studies. Results were categorized by subject and then an overall effect size for all studies was calculated. These results indicated that one-to-one laptop programs had an overall positive impact on academic achievement across all subjects and the results were statistically significant in all subjects except for reading. While these effect sizes are statistically significant, the researcher did address the fact that in the area of educational statistics, the reported effect sizes are considered small. This meta-analysis adds to the understanding of the potential impact of one-to-one laptop programs on student achievement; however it does not address the specific uses of the laptops in these settings in order to achieve these results.

Effects of Computer-Based Feedback

As Varier et al. (2017) noted in their study, teachers found that they had increased opportunities for immediate formative feedback when students had their own device in the classroom. Of particular interest to the current study, three studies were found that investigated the effectiveness of using of computer-based assessments to provide this immediate feedback (Alcoholoda et al., 2016; Maier et al., 2016; Sheard & Chambers, 2014). Maier et al. (2016) found that the nature of feedback provided to biology students in a computer-based assessment program may impact the value students get from the feedback. They found that elaborative multi-level feedback was not as effective as simple verification feedback. It was discovered that the overly elaborate feedback was not always used by the students when presented to them; however, both forms of computer-based feedback were more effective than no feedback. Furthermore, the findings surmised that in order to get through the assessment more quickly, students would often not read the feedback. This implies that verification feedback should be immediate, but it must also be utilized by the student.

In their study, Alcoholoda et al. (2016) sought to determine how three different forms of feedback would impact the mathematic achievement of third grade students in Chile. A total of 81 students from a single school were randomly divided into three groups of 27 students each. Pre-test and post-test were used as the basis of the analysis. Of the 81 students, only 54 took both tests and were included in the final analysis. One group received arithmetic practice on a netbook (personal computer), another group used their own mouse and viewed a single shared screen projected in front of the whole class (interpersonal computer), while the last group practiced with pen and paper workbooks. The students that worked in both of the computer groups used an arithmetic drill program. The only difference between these two groups was the nature of the feedback given being private or public. The public feedback used coded symbols so as to maintain student confidentiality while presenting the results to the entire class. The program presented students with at least 15 arithmetic problems divided by units that they would work through at their own pace and the students had to enter their answers in a grid rather than select a multiple choice so as to prevent guessing. The system then provided feedback immediately on the screen. Progress toward the unit completion was indicated as color-coded boxes on the side of the screen. Students would get a green box if they answered correctly on the first attempt, yellow if they answered correctly on the second attempt, and red for a correct answer on three or more attempts. This information was also monitored by the teacher who also provided assistance as needed which provided an additional form of feedback. Another aspect of the system was that students had to work the current problem correctly before moving on. Students, therefore, may be required to answer more than 15 questions per unit. The paper and pencil group had to work the entire set of 15 problems before they could check their answers in the booklet, and may not receive any feedback from the teacher until after they had submitted their work for review. It was also noted that some students did not check their answers at all. The results indicated that all three groups showed positive gains with the interpersonal computer scores improving by 54.44% from the pre-test score, personal computer users improving by 50.62%, and the paper-and-pencil group improving by 27.23%. Researchers found that the interpersonal and personal computer groups performed statistically better than the paper-and-pencil group and that there was no statistical difference in the two computer-based groups. This indicated that the public versus private feedback was not a factor; rather it was the immediacy of the feedback that made the difference. These findings add to the understanding of the role that CBFA can play in increasing the availability of immediate feedback and thus increasing student achievement. As the teachers in this study were required to use one of the three formats in a prescribed fashion, teacher autonomy in selecting when and how to use CBFA in their classroom was not considered. The current study will seek to fill this gap in the research.

In their mixed methods experimental study, Sheard and Chambers (2014) sought to determine if a handheld cloud-based feedback system could improve student grammar and writing achievement for fifth grade students. They were also interested in determining if the system produced statistically different results for students of high, average, or lower ability levels. The researchers selected one classroom from 42 different schools in England. Each of these schools was match paired with another school in this group that was similar in demographics and then they randomly assigned one school to be in the control group (did not use assessment system), and the other to be in the experimental group (used assessment system). This resulted in 21 schools in each group in which one fifth grade class was randomly selected from each school. Each teacher in the experimental group received hands-on training and supplemental online training prior to the start of the study. A grammar pre-test was given to all students in both groups and an equivalent post-test was created to measure growth. Additionally, student and teacher interviews as well as classroom observations were conducted with 11 intervention classes and 11 control classes in order to determine perceptions on assessment and teaching methods. Surveys were also conducted with students and teachers in the experimental group to collect perceptions of the assessment system effectiveness with grammar and writing achievement. Test score data were compared using ANCOVA to determine if there were differences in achievement between the two groups from pre-test to post-test, controlling for initial differences in pre-test scores. Results indicated that there was a statistical difference in grammar achievement for the experimental group as measured by ANCOVA. Additionally, teacher survey results indicated that 80% of teachers felt that assessment system helped their students with grammar. The findings however found no statistical difference in writing scores, although 91% of teachers reported that the assessment system had benefited students' writing and 65% of students reported it benefited their writing. Analysis of achievement differences between high, average, or low achieving students indicated that average and low achieving students showed significant increases when compared to their matched control classes, while the high achievers showed no statistical difference. Teachers reported that their special education students seemed to improve the most and boys with behavior challenges also demonstrated improved motivation. This study is of significance because it demonstrates that immediate feedback from computer-based assessment devices can significantly improve student achievement and motivation. While this study has shown differences in outcomes of student use of assessment in grammar achievement, the current study will seek to extend this research by investigating the differences in teachers' frequency of use of CBFA for students of different ability levels across all academic subjects.

In another study, Rodrigues and Oliveria (2014) conducted a quantitative study with an experimental design to investigate a system for assessing free-text answers based on computer algorithms that are trained by teachers to recognize correct answer responses. The study evaluated the effectiveness of the program called Assisted Study (AssiStudy) used by two history teachers in several classes from 2009 through 2012 in northern Portugal. A total of 404 students trained with the AssiStudy program versus a control group of 319 students that did not. The system allowed students to type free-text responses and received feedback instantaneously. A correlation analysis between grades assigned by AssiStudy and teacher grading was conducted and showed that the system actually penalized students more than the teachers. This was not seen as a negative because according to the researchers, the motivational aspect of the program appeared to encourage students to study harder. The researchers used t-tests to compare end of unit scores of the two groups of students. The results of the study indicated that students that were trained with the AssiStudy program had higher academic performance on end of unit exams compared to the control group that only had traditional forms of feedback. Results were attributed to the timely feedback provided to the students as compared to waiting for teachers to read and grade the responses. Additionally, computer-based feedback was noted to provide more consistent grading of answers and corresponding feedback versus teacher grading due to the potential of teacher grading fatigue. Another finding indicated that students enjoyed training on the system and teachers recognized that the system relieved their workload. This study will add to the understanding of computerized feedback and the teacher-perceived usefulness of technology in the current study. This study was limited by the small number of participants and did not address the teacher frequency of use of the program. The current study will seek to close this gap in the research.

In their quantitative experimental designed study, Maier et al. (2016) examined the effect of multi-tiered computer-based formative assessments to determine if students would benefit from instantaneous elaborate feedback, simple correctness of the answer, or a control group that did not have multi-tiered questions provided. The study took place in six Bavarian schools, which included ten secondary classrooms with a total of 261 biology students. Multiple choice tests were created using Moodle and consisted of three levels of multiple choice questions that were designed to test conceptual knowledge. Students were divided into three treatment groups: The T1 group was an elaborated feedback group that received information immediately after answering each question that included the correct answer and an explanation of why it was the right answer. The T2 group only received information on the correctness of their answer without feedback. The T3 group had to read texts on the computer rather than take the formative assessments. Additionally, students in the T1 group were further divided into two sub-groups, T1A and T1B. Subgroup T1A indicated that they had read and used the feedback in order to answer additional questions. Subgroup T1B indicated that they did not find the feedback helpful, but did see which answer was correct. The researchers conducted correlation analysis and one-way analysis of variance, which indicated that students in group T1A and T2 scored significantly higher on the conceptual post-test than students in T1B or T3. This supported the hypothesis that elaborated feedback is only useful when the students perceive it as helpful and use it to think about their learning. Elaborate feedback was equally effective as verification feedback only. Explanations for this result that were provided by the researchers included: the length of the feedback may have been too long and students did not read it, the elaborated feedback may not have been needed since students may have been able to determine what they did wrong by simply seeing the correctness of their response, and finally, the elaborated feedback might be helpful but not in the format presented within the formative assessment. These results implied that in order for formative assessment to be effective, students must find the feedback helpful.

Current Computer-Based Formative Assessment Practice

Conducting frequent non-graded formative assessments to an entire class, analyzing the data, and then making adjustments to instruction is a time consuming process for teachers and can make this activity less likely in practice (Birenbaum et al., 2011; Box et al., 2015; Cotton, 2017; Havnes et al., 2012; Lee et al., 2012). With formative assessment, there are two primary goals, the first, assess the current level of each individual student, and second provide individualized instruction based on that data (Black & Wiliam 1998a). This is where CBFA can be extremely helpful in a one-to-one setting. With the ability to quickly assess each student and then to present custom feedback responses, either automatically or from the teacher, the CBFA systems currently available may be able to provide better support of the learning goals of teachers and students related to more frequent formative assessment usage.

Student Response Systems

Student response systems (SRS), also known as "clickers" have been used in classrooms for some time (Lee et al., 2012). These devices allow teachers to quickly poll a class of students in order to obtain data relative to learning goals. The system will then display the data to the classroom in a bar graph form so the teacher can make immediate instructional decisions relative to the class as a whole and students can get feedback on the correct answer. Fuller & Dawson (2017) found that middle school students using the handheld devices were more engaged during the learning process and the publicly charted results seem to keep the students accountable for their learning even though it was presented anonymously, because they knew that the teacher could review the individual data at anytime. These findings are consistent with previous studies on the positive effects on student motivation and engagement when using technology in the classroom (Ertmer et al, 2012; Tas, 2017; Varier et al., 2017).

With the emergence of Web 2.0 tools, a variety of web-based SRS have become available for teachers to use in their classrooms and share many of the features of clickers. With these, students can access the applications from a variety of devices, such as mobile phones, laptops, or tablets, many of these programs are free, while others may require a paid subscription (Fuller & Dawson, 2017; Shute & Rahimi, 2017). These applications, like the clickers, collect student response data and compile the results into charted data that allows teachers to make immediate instructional adjustment as well as provide feedback to students in the form of teacher-led discussion. Two such programs that will be discussed here as examples are Socrative and Kahoot!.

Socrative

Socrative is a Web 2.0 tool that allows teachers to create an account to record and maintain questions as well as data responses from their students for analysis. There is a limited free version or teachers may pay for additional access. Students can access the program from any internet connected device. Students are given instructions to download the student login application and then the teacher provides the students with a number that allows them to log in to the teacher's classroom. The teacher must create their own assessments in a variety of formats. The formats include: multiple-choice, true-false or free response assessments, and they also have the option to present single questions for quick polling of students. Wash (2014) found that the students in her study noted that the program helped increase participation in class, helped to provide instant feedback, and increased mental engagement in class and that students felt more comfortable answering questions through the use of the response system rather than calling out answers.

Kahoot!

Kahoot! is a game-show style application that is very similar to Socrative, in that it is a free Web 2.0 application that allows teachers to establish an account for the purpose of creating their own online assessments and collecting student response data. Students can join an assessment by entering the web address of the Kahoot! site, and then entering the assessment key, which is provided by the teacher. Students are presented with questions that they view on the classroom monitor. Students select their response on their own device. The interface presents students with music, a countdown timer, and points that are awarded for correct responses. This all combines to give the application a game-show style. Once the timer has expired, the correct answer is displayed to the class, and a chart showing the distribution of responses are presented to the class. At this point, the teacher can provide corrective feedback. Iwamoto et al. (2017) conducted an action research study with a group of 46 undergraduate psychology students from two different classes to determine if students using Kahoot! (n = 24) would score significantly higher on the post-test for the class as compared to the control group (n = 22). A survey instrument was also used at the conclusion of the course to record student perceptions related course instructional methods to determine what they felt helped them the most with the material. An independent samples t-test was conducted to compare the effect of the post-test scores between the two groups. An analysis of the survey results indicated that there where differences in the pattern of responses for the control group and the experimental group when asked about what helped them prepare for exams and comprehend the material. The control group reported that what helped them prepare for exams was PowerPoint (n = 11) followed by notes (n = 9), and finally the study guide (n = 8), while the experimental group reported Kahoot! (n = 17), notes (n = 5), and the test review (n = 8). When asked what helped them comprehend the material, the control group reported videos (n = 14), PowerPoint (n = 7), group work (n = 3), where as the experimental group reported Kahoot! (n = 10), videos (n = 7), and PowerPoint (n = 3). These results implied that the students found value in the immediate feedback provided by Kahoot! and it provided them with an understanding as to their level of learning in the classroom. They also felt more comfortable with their learning leading up to the examination. Finally, the researchers reported that students indicated that they looked forward to coming to class because they enjoyed playing Kahoot!. This study supports previous research into the motivational and academic effects of using formative assessments and technology in classrooms.

Other Web 2.0 CBFA Applications

In addition to Kahoot! and Socrative, there are numerous other Web 2.0 applications that are currently available to teachers online for free or as a paid subscription. Many of these have similar features that allow teachers to pose questions, collect student responses in various ways, and then provide instant feedback. Vincent (2016) compiled a list of several useful formative assessment applications that are currently available to teachers. A few of these are listed below along with a description of the application and the corresponding web address (see Appendix B).

Chapter Summary

In this chapter, a review of the relevant literature was presented that will inform this study. It began by examining the positive academic effects of formative assessment, explored the barriers to implementing these practices and some methods to overcome them, and examined the literature on the evolution of technology in education and the barriers, both external and internal, to integrating technology in education, including methods that have been shown to be effective in overcoming these barriers. The review continued by investigating one-to-one computing initiatives and specifically detailed the implications of such programs for district leaders, teachers, and students. The chapter concluded with a review of Web 2.0 tools that are widely available to teachers along with the potential benefit of their use on student achievement and motivation. Furthermore, while the academic impact of one-to-one computers have shown mixed results based on the specific application of the technology, the effectiveness of computer-based instruction has clearly been shown to have a positive influence on motivation. Despite the ease of accessibility to technology, barriers to implementation of the technology in the classroom continue. There remain certain teacher-specific and class-specific factors that have been shown to influence teacher choice to include instructional technology in their classroom. Prior studies have not investigated the relationships of these factors specific to the frequency of CBFA usage in a one-to-one setting and thus there exists a gap in the literature, which warrants further research.

With the widespread integration of one-to-one technology initiatives and the availability of many free and easy to use CBFA Web 2.0 tools for teachers to use with their students, a close examination of teachers' formative assessment practices in this setting are of interest to this study. The literature reviewed revealed an absence of research that describes the specifics on how often teachers are deciding to use the various Web 2.0 tools to formatively assess students and if relationships between formative assessment and technology usage found in prior studies will continue to be found in one-to-one computing settings specific to CBFA usage. While many studies have investigated the barriers to teacher use of technology in general, no research was found that has specifically investigated teacher use of CBFA and how different factors may be related to the frequency of CBFA usage by teachers in one-to-one computing settings and thus, this study is intended to close this gap.

CHAPTER THREE

METHODOLOGY

Research Design

In this correlational research study, the types and frequency of use of computer-based formative assessments (CBFA) by middle school and high school academic teachers situated in a one-to-one Google Chromebook program was studied. The results of this study are intended to provide a detailed analysis on how various factors relate to a teacher's frequency of CBFA usage in their classrooms as well as a reporting of the specific computer-based assessment programs that teachers are using with their students. As a result of the literature review, several factors have been identified that may influence a teacher's decision to use instructional technology. These factors were investigated specific to CBFA usage in this one-to-one district.

Research Questions

The following overarching and equally weighted research questions will guide this study:

1. Which CBFA applications are middle school and high school academic teachers in one mid-sized, suburban Georgia school district using in a one-to-one networked environment to formatively assess student learning?
2. Are there differences in average CBFA usage rates across teacher and course-specific factors in a one-to-one computing setting?
3. To what degree does teacher comfort with technology correlate to their frequency of use of CBFA in a one-to-one computing setting?
4. To what degree does a teacher's perceived benefit of using instructional technology in the classroom correlate to their frequency of use of CBFA in a one-to-one computing setting?

5. To what degree does teacher perceived technology support and vision correlate to their frequency of use of CBFA in a one-to-one computing setting?
6. To what degree does a teacher’s level of perceived autonomy correlate to their frequency of use of CBFA in a one-to-one computing setting?

Setting

This study's design required that participants (1) teach within a Georgia school district; (2) teach at the middle school or high school level; (3) teach one of the four core academic subjects, English, mathematics, science, or social studies; and (4) utilize Google Chromebooks with their students in a one-to-one environment. In order to achieve a district-wide representative sample, teachers from all six of the middle schools and all three of the high schools in the district that fit the selection criteria were invited to participate in the study. A total of 414 teachers were contacted through email with an explanation of the study's purpose and an invitation to join the study.

The selection of this Georgia school district was made due to use of one-to-one computing devices in this district, the researcher's access to email distribution lists as well as a professional relationship within this district. The high school and middle school academic teachers were selected due to similar class structures, the required nature of these courses, and the presence of mandated end of course assessments in some, but not all of these classes. This school district had been operating under a one-to-one computing initiative since the 2016-2017 school year.

Participants

Of the 414 teachers that received an email to ask for their participation in the study 280 responses were received. Due to missing responses only 261 of these could be used for analysis. This resulted in a response rate of 63.0%, which was more than twice the minimal response rate of 30.9% sought based on acceptable statistical standards (Cohen, 1988). Study participants included 130 middle school teachers (32 English, 39 mathematics, 31 science, and 28 social studies) and 131 high school teachers (30 English, 37 mathematics, 34 science, and 30 social studies). For years of teaching experience, 16.9% had 1 – 5 years, 18.0% had 6 – 10 years, and 65.1% had 11 or more years of experience. Of these teachers, 60.9% of them primarily taught classes with a state-mandated end of course assessment, while 39.1% did not. Class levels consisted of advanced or gifted, on-level, or collaborative classes, with 62.5% of teachers reporting they taught at least one advanced or gifted classes, 82.8% reporting that they taught at least one on-level class, and 64.4% reporting that they taught at least one collaborative class. Professional learning on how to use formative assessments within the prior 12 months was reported by 65.5% of the teachers, while professional learning on the use of instructional technology in the prior 12 months was reported by 68.2% of the teachers. Collaboration with colleagues on the use of any type of formative assessments in the prior 30 days was reported by 90.8% of teachers, and collaboration on the use of any instructional technology in the prior 30 days was reported by 81.6% of the teachers. See Table 1 for the number of teachers from each demographic category included in the study.

Table 1
Description of Teacher Responses (N = 261)

Demographic Factor	*n*	Percentage
Grade Level and Subject		
Middle School	130	49.8
English	32	24.6
Mathematics	39	30.0
Science	31	23.8
Social Studies	28	21.5
High School	131	50.2
English	30	22.9
Mathematics	38	28.2
Science	34	26.0
Social Studies	31	22.9
Subject		
English	62	23.8
Mathematics	77	29.1
Science	65	24.9
Social Studies	59	22.2
Years of Experience		
1 – 5	44	16.9
6 – 10	47	18.0
11 or more	172	65.1
Teachers with End of Course Tests	160	60.8
Middle School	98	75.4
High School	62	46.6
Teachers with each Class Level		
Advanced/Gifted	163	62.0
On-level	216	82.1
Collaborative	168	63.9
Professional Learning		
Formative Assessment	171	65.5
Instructional Technology	178	68.2
Collaboration with Colleagues		
Formative Assessment	237	90.8
Instructional Technology	213	81.6

Instrumentation

The instrument that was utilized in this study was a 38-item researcher developed questionnaire. This instrument was used to quantify the frequency of each teacher's use of CBFA in their classroom and collect data on variables identified from the literature review that had been shown to impact teacher use of technology and formative assessments. These variables included teacher-specific and class-specific information, three constructs related to the integration and support of instructional technology as well as one construct related to teacher-perceived autonomy. To ensure the alignment of the questions selected for the researcher developed questionnaire, all questions were aligned to existing research on instructional technology and formative assessment (see Appendix D) as well as the research questions guiding this study. To ensure content validity of the constructs used in this study, existing scales from two prior validated studies were used in the development of this instrument (Reinhart & Banister, 2009; Vangrieken et al., 2017). The scales used to measure *Teacher Comfort with Technology* (CWT), *Perceived Benefit in using Technology in the Classroom* (PBT), and *Technology Vision and Support* (TS) were adapted from the Teacher Technology Integration Survey (TTIS) of Reinhart and Banister (2009). Seeking a multi-dimensional approach to measure teacher technology integration, the researchers used several existing scales to develop the TTIS and created six constructs to measure teacher technology integration. For the purposes of this study, three of the constructs from their survey were used. The TTIS construct entitled Risk-taking Behaviors and Comfort with Technology consisted of nine items and was used for the current study's construct of CWT. One item from the construct was removed after pilot testing due to redundancy and the name of the construct was shortened. The five-item TTIS construct Perceived Benefit in using Technology in the Classroom was used in its entirety and the name was maintained for the construct. The TTIS construct entitled Technology Support and Access was adapted for the construct TS. This nine-item TTIS scale consisted of four questions specific to computer technology access. In a one-to-one computer setting as in this study, access to computer technology is no longer an issue, thus these four items were not used. The remaining questions were used in their entirety.

The *Teacher-Perceived Autonomy* (TA) construct was developed from the Autonomy and Collaborative Attitude Instrument of Vangrieken et al. (2017). Their 33-item instrument consisted of three constructs measuring teacher autonomy. These constructs were: didactical-pedagogical autonomy, curricular autonomy, and collaborative attitude. For the purpose of the current research study, the seven-item construct of didactical-pedagogical autonomy was used to develop the construct of TA. This construct measured general autonomy in lesson planning, instructional methods, assignments, assessments, use of time, and managing student behavior. A few of the questions were slightly reworded to be easier to read as well as to apply to the current study for example, replacing the word coursebooks with Chromebooks in one of the questions. Additionally, the question relating to classroom management was eliminated after field testing. The researcher obtained permission to use the scales from these instruments from each of the authors by email (see Appendices E and F).

The questionnaire was used to collect responses to answer the six research questions in this study. For research question one, the instrument collected data on which CBFA applications teachers were using with their students. Two items collected this data. The first item used a menu of choices to allow teachers to quickly select among the applications that they had used with their students in the prior 30 days. The second item was an open-ended question that asked the teachers to list all other CBFA applications they had used that were not listed in the prior question. This allowed the researcher to capture data on lesser-known applications that teachers were using within the specified timeframe.

To collect information needed to answer the remaining five research questions, the researcher asked the teachers to identify the number of days that the teacher had used a CBFA with their classes over the prior five instructional days. This was achieved by posing the CBFA usage rate question as three separate questions for each of the three possible class levels that the teacher may have been teaching. These levels were advanced or gifted classes, on-level classes, or collaborative classes. Responses were indicated as not applicable (NA) if they did not currently teach that level of class or was recorded as number from zero to five days. There was the possibility that teachers taught any or all of these three levels, and it was important to quantify CBFA usage separately across class levels in order to compare mean CBFA usage among these levels.

To answer research question two, eight items collected teacher-specific and class-specific descriptive data. These items included questions on: years of teaching experience, subject and grade level taught, identification of teachers that taught at least two courses that had a state-mandated end of course assessment, professional learning background in formative assessment and/or instructional technology, and collaboration with other teachers on formative assessment and/or instructional technology. Teachers selected their number of years of teaching experience from three choices based on one of three career stages: one - five years, six - 10 years, or greater than 11 years (Richards, 2005). Each teacher then selected the subject that they primarily taught (English, mathematics, science, or social studies), and the primary grade level that they taught (high school or middle school). The next two questions asked teachers if they had received any professional learning on instructional technology or formative assessment within the prior 12 months, choices were either yes or no. The next two questions asked the teacher if they had collaborated with other teachers on instructional technology or formative assessments within the prior 30 days, choices were either yes or no. The final question of this section determined if the teacher currently taught at least two classes that had a state-mandated end of course test (EOCT). This wording was selected for the ease of categorization of the teachers into two groups, those that primarily taught (at least 50%) EOCT classes and those that did not. At the middle school level, teachers that answered yes to this question had a teaching schedule that consisted of at least half of their classes containing an end of course assessment, while at the high school level, at least two-thirds of their teaching schedule consisting of EOCT classes. To further explore the possible differences in usage rates among class levels, an open-ended question asked study participants that reported such a difference to describe why they used CBFA at different rates for the three different class levels that they taught. The wording of this question was: "If you reported in Q1, Q2, and Q3 that you are using CBFA at different rates over the last five days for different class levels (advance/gifted, on-level, or collaborative classes), please describe the reasons for the different usage rates."

The third part of the instrument consisted of eight items which collected data used to answer research question three and measured the construct of *Teacher Comfort with Technology* (CWT). This construct related to teacher comfort in using instructional technology with students, comfort with troubleshooting technology, and teacher confidence in learning new technologies on their own. This measure along with the constructs for the fourth and fifth parts of this instrument was adapted from an existing validated instrument from Reinhart and Banister (2009). Those researchers determined content validity through a panel of experts who investigated the content, structure, and language of their final instrument. Confirmatory factor analysis using principal component analysis confirmed that their scale loaded on six factors. Confirmatory factor analysis is used to determine if individual items on a questionnaire are forming patterns of responses known as factors as factor loading scores will range from zero to one, the higher the number, the better the alignment of the item to the factor (De Vaus, 2002). The items related to the factor CWT all loaded at or above an acceptable measure of .596. Additionally, they measured internal reliability using Cronbach's alpha. Cronbach's alpha is used to measure the consistency of a person's response of one item in the construct to their answers to other items in the same construct to determine if the questions are returning consistent responses. Cronbach's alpha is measured on a scale from zero to one, the higher the number the better the consistency between the responses of individual participants (De Vaus, 2002). Cronbach's alpha was calculated at an acceptable measure of .854.

The fourth part of the instrument contained five items and collected data to answer research question four. These items were used to measure the construct of *Perceived Benefits of Using Technology in the Classroom* (PBT). These items related to teacher belief in technology to enhance student learning, to increase teacher effectiveness, to motivate students, and to increase communication with students. Through confirmatory factor analysis, Reinhart and Banister (2009) found that items for this construct all loaded at or above .611, which indicated an acceptable alignment of these items to the factor. Cronbach's alpha was used to measure internal reliability at an alpha level of .849, which indicated consistency in the responses for these items.

The fifth part contained five items and collected data to answer research question five. These items were used to measure the construct of *Teacher-Perceived Technology Support and Vision* (TS). The five items chosen for this construct were selected as part of a nine-item scale from Reinhart and Banister (2009) that measured technology support and access. The questions related to access were not used for the current study as the issue of access to computers is not applicable in a one-to-one computing environment. The questions related to technology support referred to a shared school technology vision, the availability of technical assistance, and school leadership technology policies. The factor loading of the five items used for this construct were all greater than .661, which indicated acceptable alignment of these items with the factor, and the factor loading of the four items that were not used ranged from .290 to .422, which indicated less alignment of these items with the factor. Internal reliability as measured by Cronbach’s alpha of the nine-item scale was measured at an alpha of .660, which indicated acceptable consistency of the responses for these items.

The sixth part of the instrument collected data to answer research question six. These items were used to measure the construct of *Teacher-Perceived Autonomy* (TA). The seven items chosen for this construct were adapted from the validated instrument of Vangrieken et al. (2017). The researchers created their instrument to measure the constructs of teacher autonomy and teacher collaboration. For the purposes of the current research instrument, only the teacher autonomy scale, which they referred to as didactical-pedagogical autonomy was utilized. These items related to teacher-perceived autonomy in lesson planning, selection of instructional methods, assignments, choice of assessment methods, time and behavior management, and use of textbooks or technology. Content validity for the teacher autonomy scale was confirmed by the researchers through extensive scientific research of the relevant literature and by using previously validated scales that matched their conceptual framework of teacher autonomy. Confirmatory factor analysis verified the underlying structure of their instrument and established three unique factors. The factor loading for the teacher autonomy items were all greater than .517, which indicated acceptable alignment of these items to the factor. Internal reliability was confirmed with a Cronbach's alpha of .83, which indicated that the items in the construct had consistent responses from the participants.

Pilot Study

A pilot study was conducted with teachers drawn from the target population to determine if revisions to the original 39-item instrument were needed. An attempt was made to ensure approximately equal numbers of middle school and high school teachers as well as an equal number of teachers from each of the four subject areas. The researcher selected teachers who fit this criterion who also had familiarity with the researcher in order to increase the participation rate. The researcher emailed an invitation to a total of 18 teachers in the district; 10 middle school teachers and eight high school teachers from across the four academic subject areas to seek their consent to participate in the pilot study. After receiving their consent to participate, the draft version of the instrument was sent to each teacher along with three additional questions to guide their feedback to the researcher. Each teacher was then asked to submit the questionnaire electronically within a week. After three days, a reminder was sent to all teachers who had not responded by that time reminding them of the requested due date and thanking them again for their participation. At the end of the week, a total of 17 teachers had taken part in the pilot study. This included teachers from each of the four subject areas from both middle school and high school. Suggestions from the participants of the pilot study were provided based on the three guiding questions: (1) "How many minutes were needed to complete the questionnaire?"; (2) "Were there any questions that were confusing or worded oddly? Any that you felt were redundant?"; and (3) "Was the format easy to follow? Suggestions for improvement?". Participants reported that the design was easy to follow and the questions seemed to relate well to the intent of the study. Based on the feedback provided, two questions were eliminated due to redundancy, and two questions as well as the introductory directions, were slightly reworded to make them easier to understand. Additionally, from the CBFA applications reported by these teachers, several additional option choices were added to the question related to the specific CBFA used by teachers in the prior 30 days.

As a result of the pilot testing the following two questions were deemed to be confusing or redundant by the participants and were removed from the instrument, "In my classes, I am responsible for time management", and "I get anxious when using technology with my students." Two items were reverse scored and then Cronbach’s alpha was calculated for the questions representing each of the four intended constructs. The eight items representing the first construct, CWT returned an alpha of .860. The five items for PBT returned an alpha of .706. The five items for TS returned an alpha of .823. Finally, the six items related to TA returned an alpha of .839.

At the conclusion of the initial pilot testing, an additional open-ended question was field tested and added to the instrument that sought to determine why teachers that reported different usage rates among the different levels of classes that they taught (advanced/gifted, on-level, collaborative) where choosing to do so. The initial question asked; "If you reported using CBFA at different rates over the last five days for different class levels (advance/gifted, on-level, or collaborative classes), please describe the reason for the different usage rates." This question was field tested by emailing the question to six teachers that took part in the initial pilot testing to determine if the question was understandable and would provide the desired responses. After reviewing the feedback, the question was reworded as follows to make it easier to understand what it was asking; "If you reported in Q1, Q2, and Q3 that you are using CBFA at different rates over the last five days for different class levels (advance/gifted, on-level, or collaborative classes), please describe the reasons for the different usage rates."

After revisions, the final instrument contained a total of 38 questions (see Appendix C). All 11 of the teacher-specific and class-specific questions were retained, CWT contained eight items, PBT contained five items, TS contained five items, and TA contained six items. The last two questions were reworded and maintained in the final instrument and the additional open-ended question asking the reasons why they reported different CBFA usage rates among the different class levels that they taught was added. Based on pilot testing, the questionnaire took participants approximately ten minutes to complete.

Data Collection

Prior to data collection, the researcher obtained all required permissions to conduct the study. First, the researcher requested a Letter of Cooperation (LOC) from the school district's Associate Superintendent to allow access to and use of an internal email distribution list to communicate with the population of teachers that fit the selection criteria in the study for the duration of the data collection period. Secondly, the researcher obtained institutional review board (IRB) approval from the research institution in order to secure permission to conduct the study. The participants were asked to complete the questionnaire to determine how often they are using computer-based formative assessments in their classrooms and which specific CBFA programs they were currently using. Descriptive data such as grade level taught (middle or high), years of teaching experience, recent professional learning and collaboration in formative assessment and instructional technology, subject taught, and types of classes taught were collected. Participants were also asked to complete several four-point Likert-type scale questions related to their comfort in using instructional technology, their perceived benefits in using technology in the classroom, technology support, and teacher perceived autonomy. The next two questions of the instrument asked the participants about the CBFA applications that they had utilized recently in their classrooms. One question allowed participants to select from several listed applications and the last question was open-ended and asked the participant to list any other CBFA applications that they utilized recently that were not listed in the prior question. A final open-ended question asked the participants to discuss why they may have used CBFA at different rates with their different class levels.

Sample size. Using statistical standards for calculating an acceptable sample size to represent a population, the researcher set an alpha level of 0.05 and a power level of 0.80. In order to detect a medium effect size, effect sizes for the t-test, ANOVA, and Pearson r were set at 0.50, 0.09, and 0.30 respectively. Using these parameters, the acceptable sample size for this study was determined to be 128 participants (Cohen, 1988).

Response rate. The response rate was calculated as the number of returned, usable participant questionnaires divided by the number of participants that were sent questionnaires. The minimum acceptable response rate was set at 128/414, which resulted in a targeted response rate of at least 30.9%. In order to maximize the response rate, the researcher did the following: used an easy to use online instrument created in Qualtrics; maintained a short data collection window; provided a follow-up email reminder to complete the questionnaire; and gave each participant that opened the questionnaire the opportunity to be included in a drawing for one of four $50 Amazon gift cards that was given away at the conclusion of the data collection phase as an incentive to participate in the study.

Prior to data collection, the researcher sought the cooperation of the principals of the schools in the study by sending an email to each of them explaining the purpose of the study and the significance to the district. The email included a request to encourage their teachers to participate. At the outset of the data collection phase of the study, each member of the target population was sent a descriptive recruitment email (see Appendix G) to explain the purpose of the study, the rationale for their inclusion in the study, an explanation of the incentive offer to participate in the study, an opt out opportunity, and a link to the online questionnaire which if completed, posed no risks greater than everyday life for the participants. The researcher attained implied consent from participants to take part in the study if they choose to submit a survey. After one week, a follow-up reminder email (see Appendix H) was sent to all teachers in the target population. This email included the link to the online questionnaire, a reminder of the incentive offer, and another request to submit responses within a week if they had not already done so. This process resulted in each member of the target population receiving a total of two emails over the course of two weeks with the questionnaire attached as a link each time.

All 414 members of the population were invited to participate in the study through email. In order to encourage participation and to increase the response rate, each participant that completed the questionnaire had the opportunity to be included in a drawing for one of four $50 Amazon gift cards that was given away at the conclusion of the data collection phase. At the end of the questionnaire, a message along with a code appeared to participants and served to provide confirmation that they had successfully reached the end of the questionnaire. Each participant was then directed to register for the drawing through a separate contact information form. The information that was collected included their name, school assignment, their email address, and submission code. A unique number was assigned to each participant in the order in which they submitted their contact information. The researcher recruited a staff member that was not part of the study to use a random number generator to select four numbers that would represent the four winners of the $50 Amazon gift cards. Those that submitted a form for the drawing were notified of the results of the drawing and the gift cards were sent to the four winning teacher's schools by intra-school courier.

Responses to items on the instrument were quantified in order to permit statistical data analysis. For research questions one through three, the number of days of CBFA used over the prior five days across different class levels were recorded. Each response was limited to a number between zero and five. A response of not applicable (NA) was converted to a non-response by deleting that response prior to analysis and the mean CBFA usage for these teachers was calculated only for responses given. For item four, years of teaching experience, "1 - 5 years" was coded 1, "6 - 10 years" was coded 2, and "more than 11 years" was coded 3. Item five, *grade level*, was coded, middle school = 1, and high school = 2. For item six, subject, English was coded 1, mathematics was coded 2, science was coded 3, and social studies was coded 4. For items 7 - 11, a response of "no" was coded 0, and a response of "yes" was coded 1. For items 12 - 35, a 4-point Likert-type scale was used, with Strongly Agree = 4, Agree = 3, Disagree = 2, and Strongly Disagree = 1. The next two items asked participants to identify which CBFA assessments they had used in the prior 30 days. The first of these items gave the participants a choice of several CBFA applications that had been identified through the literature and/or the pilot study. The next item on the instrument was open-ended and asked participants to list any other CBFA not listed in the prior question that they had used in the prior 30 days. The last item was opened-ended and sought to determine the reasons that teachers may have been using CBFA at different rates across their classes of different academic levels.

Chapter Summary

In this correlational study, the researcher used a quantitative approach to determine the types and frequencies of CBFA usage of a population middle and high school academic teachers in a one-to-one technology school district in Georgia and investigated differences among several groups. A sample of 261/414 academic teachers submitted responses that were used in the data analysis for this research study for a 63% response rate. A researcher-compiled questionnaire was used to collect this data and was used to investigate the factors that correlate to the frequency of CBFA usage by these teachers, including teacher comfort with, belief in, and support of instructional technology as well as teacher-perceived autonomy. This study also investigated which CBFA applications teachers were using with their students and examined relationships among the variables along with differences in CBFA usage between groups of teachers in each of the three class levels that the teachers may have taught. This study is intended to extend the research on formative assessment usage and instructional technology usage by teachers and more closely examine how teacher beliefs, background, professional learning, and collaboration are related to CBFA usage rates in this district. It is understood that this study has certain limitations with regard to the applicability to other school systems, the accuracy of the self-reported responses, and the limited duration of the study.

CHAPTER 4

DATA ANALYSIS

This chapter will present a summary of the findings of this research study. The chapter will begin with a review of the six research questions that guided this study and a summary of the research design. An explanation of the methods of data analysis will follow and this chapter will conclude with a presentation of the research findings.

The purpose of this correlational study is to investigate the CBFA practices of core academic teachers within a one-to-one computing environment in one mid-sized suburban Georgia school district to better understand the relationships between teacher usage rates of CBFA in their classrooms and their beliefs and attitudes toward technology. By understanding the frequency at which teachers in this setting were choosing to use CBFA and the factors that influenced their decisions to use them with their students, school leaders can better develop and implement professional learning opportunities for teachers that will support their usage of these instructional technology resources.

Research Questions

With the widespread availability of high speed internet in schools along with the introduction of inexpensive personal computing laptops, an increasing number of school districts have opted to implement one-to-one computing initiatives. Concurrent with this technological advancement in access to technology has been the development of a wide assortment of web-based assessment tools that teachers may choose to use with their students to formatively assess their learning. Because there was a lack of research that investigated the types of CBFA applications teachers were using and the factors that influenced the frequency of teacher use of these applications, this research focused on frequency of CBFA usage across a variety of teacher and class specific factors to investigate how often teachers chose to use this instructional tool.

The teachers in this study were asked to complete a questionnaire that quantified their CBFA usage for each of their different class levels (advance/gifted, on-level, collaborative), collected information on which application teachers of different subjects and grade levels were using, and collected a variety of teacher and class specific factors that may have influenced teacher choice to incorporate CBFA into their classroom. The research questions were:

1. Which CBFA applications are middle school and high school academic teachers in one mid-sized, suburban Georgia school district using in a one-to-one networked environment to formatively assess student learning?
2. Are there differences in average CBFA usage rates across teacher and course-specific factors in a one-to-one computing setting?
3. To what degree does teacher comfort with technology correlate to their frequency of use of CBFA in a one-to-one computing setting?
4. To what degree does a teacher's perceived benefit of using instructional technology in the classroom correlate to their frequency of use of CBFA in a one-to-one computing setting?
5. To what degree does teacher perceived technology support and vision correlate to their frequency of use of CBFA in a one-to-one computing setting?
6. To what degree does a teacher's level of perceived autonomy correlate to their frequency of use of CBFA in a one-to-one computing setting?

Findings

The research findings in this chapter are presented in several sections related to each of the six research questions. These findings addressed the overarching research questions related to the types of CBFA teachers were using with their students, determining if teachers with different demographic backgrounds were using CBFA at different rates, and how the constructs of teacher comfort with technology, teacher belief in the benefit of instructional technology, teacher-perceived technology support and vision, and teacher autonomy correlated to the frequency of CBFA usage across class levels and teacher average CBFA use for the teachers in this study.

Types of CBFA Applications Used

The first research question was: Which CBFA applications are middle school and high school academic teachers in one mid-sized, suburban Georgia school district using in a one-to-one networked environment to formatively assess student learning? To address this research question, four frequency tables (see Tables 2 through 5) were created for each of the four academic subjects at the middle school and high school levels to indicate how many teachers reported that they had utilized each CBFA application within the prior 30 days. Overall results indicated that teachers from all four subject areas across both grade levels were using a wide variety of CBFA applications with their students. The three most commonly reported CBFA applications used by teachers in the study were Google Forms Quiz used by 77% of the teachers, followed by Kahoot! (Kahoot.com) at 61%, and then Quizlet Live (quizlet.com/live) with 51% of teachers using this application in the prior 30 days. Google Forms Quiz was reported as either the first or second most commonly used CBFA application reported in all subjects at both the high school and middle school levels and was ranked first for each of the four subjects overall. The highest reported use of a single CBFA application by any group was the application IXL for math (www.IXL.com) used by 97.4% of the middle school mathematics teachers in the study. The group with the least reported overall use of CBFA applications was the high school mathematics teachers. This group reported that 18.9% of them had not used any CBFA applications with their students over the prior 30 days. The most used application for this group was Google Forms Quiz used by 62.2% of these teachers. High school social studies teachers and science teachers also reported lower CBFA usage rates compared with the other groups in the study, with 13.3% and 5.9% of these teachers respectively reported using no CBFA applications with their students in the prior 30 days. Kahoot! was reported as one of the most used applications in each of the eight subject and grade level groups. It was ranked first for high school social studies teachers with 80.0% of them reporting use of the application. For overall use across the four subjects, Kahoot! was ranked either the second or third most frequently reported application. Among the self-reported CBFA applications that were reported that were not available as a selection on the questionnaire, CK12 (www.ck12.org) was the highest ranked application reported by any group. Science teachers at the high school and middle school levels reported using this program at 19.4% and 51.6% respectively.

Table 2

CBFA Applications Used by Sixty-Two English Teachers

	High School		Middle School		Total	
Application Name	*n*	Percent	*n*	Percent	*n*	Percent
Google Forms Quiz	25	83.3	28	87.5	53	85.5
Kahoot!	22	73.3	19	59.4	41	66.1
Quizlet Live	16	53.3	18	56.3	34	54.8
GCA Item Bank	9	30.0	23	71.9	32	51.6
Quizizz	8	26.7	20	62.5	28	45.2
IXL	3	10.0	23	71.9	26	41.9
No Red Ink	16	53.3	9	28.1	25	40.3
USATESTPREP	3	10.0	21	65.6	24	38.7
Formative	10	33.3	14	43.8	24	38.7
GimKit	8	26.7	13	39.4	21	33.3
CommonLit	7	21.2	3	9.4	10	16.1
Actively*	1	3.3	4	12.1	5	7.9
STAR Reader*	3	10.0	0	0	3	4.8
ReadWorks*	1	3.3	2	6.3	3	4.8
Read Theory*	1	3.3	2	6.3	3	4.8
Socrative	1	3.3	1	3.1	2	3.2
PearDeck*	0	0	2	6.3	2	3.2
None Used	1	3.3	0	0	1	1.6

Note. * Denotes items that were written responses offered by participants. Responses are from 30 high school English teachers and 32 middle school English teachers.

Table 3

CBFA Applications Used by Seventy-Six Mathematics Teachers

Application Name	High School		Middle School		Total	
	n	Percent	*n*	Percent	*n*	Percent
Google Forms Quiz	23	62.2	31	79.5	54	71.1
IXL	12	32.4	38	97.4	50	65.8
Kahoot!	13	35.1	23	59.0	36	47.4
USATESTPREP	9	24.3	27	69.2	36	47.4
Quizizz	8	21.6	25	64.1	33	43.4
Quizlet Live	10	27.0	18	46.2	28	36.8
GCA Item Bank	5	13.5	19	48.7	24	31.6
Formative	4	10.8	15	38.5	19	25.0
Prodigy	0	0	14	35.9	14	18.2
GimKit	0	0	10	25.6	10	13.0
None Used	7	18.9	1	2.6	8	10.5
DeltaMath*	5	13.5	0	0	5	6.6
Desmos*	1	2.7	3	7.7	4	5.3
Socrative	4	10.8	0	0	4	5.3
Edgenuity*	2	5.4	1	2.6	3	3.9
Plickers	0	0	3	7.7	3	3.9
Albert.io*	2	5.4	0	0	2	2.6

Note. * Denotes items that were written responses offered by participants. Responses are from 37 high school mathematics teachers and 39 middle school mathematics teachers.

Table 4

CBFA Applications Used by Sixty-Five Science Teachers

	High School		Middle School		Total	
Application Name	*n*	Percent	*n*	Percent	*n*	Percent
Google Forms Quiz	26	76.5	23	74.2	49	75.4
Kahoot!	19	55.9	22	71.0	41	63.1
Quizlet Live	12	35.3	21	67.7	33	50.8
USATESTPREP	5	14.7	27	87.1	32	49.2
Quizizz	11	32.4	18	58.1	29	44.6
Formative	13	38.2	15	48.4	28	43.1
GCA Item Bank	5	14.7	18	58.1	23	35.4
CK12*	6	19.4	16	51.6	22	33.8
GimKit	3	8.8	16	51.6	19	29.2
Socrative	6	19.4	2	6.5	8	12.3
NearPod	2	5.9	4	12.9	6	9.2
Plickers	2	5.9	2	6.5	4	6.2
AP Classrooms*	4	11.8	0	0	4	6.2
Edgenuity*	2	5.9	0	0	2	3.1
None Used	2	5.9	0	0	2	3.1

Note. * Denotes items that were written responses offered by participants. Responses are from 31 high school science teachers and 34 middle school science teachers.

Table 5

CBFA Applications Used by Fifty-Eight Social Studies Teachers

	High School		Middle School		Total	
Application Name	*n*	Percent	*n*	Percent	*n*	Percent
Google Forms Quiz	20	66.7	25	89.3	45	77.6
Kahoot!	24	80.0	18	64.3	42	72.4
Quizlet Live	16	53.3	23	82.1	39	67.2
USATESTPREP	11	36.7	20	71.4	31	53.4
Quizizz	11	36.7	20	71.4	30	51.7
GimKit	12	40.0	18	64.3	30	51.7
GCA Item Bank	11	36.7	17	60.7	28	48.3
Formative	10	33.3	10	35.7	20	34.5
NearPod	3	10.0	9	32.1	12	20.7
Gallopade*	1	3.3	3	10.7	4	6.9
None Used	4	13.3	0	0	4	6.9
AP Classrooms*	3	10.0	0	0	3	5.2
Socrative	2	6.7	1	3.6	3	5.2
Plickers	0	0	2	7.1	2	3.4
ActiveClassroom*	2	6.7	0	0	2	3.4

Note. * Denotes items that were written responses offered by participants. Responses are from 30 high school social studies teachers and 28 middle school science teachers.

CBFA Usage Rates Compared Across Demographic Factors

The second research question was: Are there differences in average CBFA usage rates across teacher and course-specific factors in a one-to-one computing setting? To address this research question eight teacher and course factors were compared for each of the CBFA usage rates for the three class levels (advanced/gifted, on-level, or collaborative) and for teacher average CBFA usage. For the first two factors, a one-way ANOVA was used to determine if teachers were using CBFA at different rates based on the subject that they taught (English, mathematics, science, social studies), or based on their years of teaching experience (1 - 5, 6 - 10, greater than 11). For the remaining six descriptive factors, independent samples t-tests were used to determine if there were differences in CBFA usage rates across class levels and teacher average CBFA use for these factors. These factors were: grade level taught (middle school or high school), identification of teachers that predominately taught courses that had a state-mandated end of course assessment (yes or no), professional learning background within the prior 12 months in formative assessment or instructional technology (yes or no), and collaboration with other teachers on formative assessment or instructional technology within the prior 30 days (yes or no).

Differences in CBFA Usage Rates by Subject

A one way ANOVA was used to determine if differences in mean CBFA usage rates existed for each level of class as well as the overall average teacher CBFA usage rate for each academic subject. These results indicated that there was a statistically significant difference in mean CBFA usage rate at the .05 level for the teacher average use of CBFA for teachers that taught different subjects. English teachers were using CBFA at statistically significant higher rates than mathematics teachers. English teachers also demonstrated the highest CBFA usage rates overall, followed by social studies teachers, then science teachers, and the lowest rate of CBFA usage was reported by mathematics teachers. The analysis across the three different class levels indicated that there was no statistically significant difference in CBFA usage rates for different subjects for the advanced/gifted classes, for the collaborative classes, or for the on-level classes. While not significant, mean CBFA usage rates across subjects for advanced/gifted, on-level, and collaborative classes indicated a very similar pattern of usage as found with the teacher overall average usage. For teachers that participated in this study at each of these class levels, English teachers reported the highest mean in all three class levels followed by social studies teachers while mathematics teachers reported the lowest usage rates for the advanced/gifted and on-level classes. Finally, science teachers had the lowest mean usage rate for the collaborative classes. It is noted that since these differences were not significant, these results could be due to chance, or due to the particular configuration of teachers in the study. The results of this analysis can be found in Table 6.

Table 6

ANOVA Results and Descriptive Statistics for Class Levels of CBFA Usage by Subject

	Advanced/Gifted Classes				Collaborative Classes			
Subject	*M*	*SD*	*n*		*M*	*SD*	*n*	
English	2.49	1.34	45		2.46	1.43	39	
Mathematics	1.63	1.62	43		2.16	1.70	51	
Science	2.00	1.43	36		2.08	1.40	39	
Soc. Studies	2.23	1.55	39		2.33	1.46	39	
Source	SS	df	MS	F	SS	df	MS	F
CBFA	17.41	3	5.80	2.62	3.63	3	1.21	.525
Error	352.21	159	2.22		377.87	164	2.30	

	On-Level Classes				Teacher AVG CBFA			
Subject	*M*	*SD*	*n*		*M*	*SD*	*n*	
English	2.42	1.27	45		2.46	1.30	62	
Mathematics	1.86	1.80	65		1.78	1.71	76	
Science	2.09	1.49	55		2.14	1.40	65	
Soc. Studies	2.29	1.45	51		2.28	1.38	58	
Source	SS	df	MS	F	SS	df	MS	F
CBFA	9.97	3	3.32	1.40	17.54	3	5.85	2.71*
Error	503.97	212	2.38		554.92	257	2.16	

*p < .05

Differences in CBFA Usage Rates by Years of Experience

Results of the ANOVA analysis of CBFA usage rates by years of teacher experience found that there was no statistically significant difference in mean CBFA usage by years of experience for teachers of advanced/gifted classes, for on-level classes, for collaborative classes, or for teacher average CBFA usage. While not statistically different, a consistent pattern of usage rates by years of experience was found by comparatively examining the mean CBFA usage rate across class levels for the three experience levels. Findings indicated that for advanced/gifted, on-level, and teacher average usage rates, teachers that had between one to five years of experience were using CBFA at the highest mean rate, followed by teachers with six to ten years of experience, and those with more than 11 or more years were using CBFA at the lowest rate. The one exception to this finding was found for teachers in collaborative classrooms where the mean CBFA usage rates for this class level indicated that teachers with six to ten years of experience had the highest rate, followed by teachers with 11 or more years, and teachers with one to five years demonstrating the least usage. Because these differences were not significant for the participants of this study, it is possible that these patterns of usage could be a result of chance. Results of this analysis can be found in Table 7.

Table 7

ANOVA Results and Descriptive Statistics for Class Levels of CBFA Usage by Years of Experience

	Advanced/Gifted Classes				Collaborative Classes			
Years of Exp		*M*	*SD*	*n*		*M*	*SD*	*n*
1 to 5		2.37	1.21	27		2.16	1.50	26
6 to 10		2.12	1.68	26		2.36	1.53	36
11 or more		2.02	1.54	110		2.23	1.52	106
Source	SS	df	MS	F	SS	df	MS	F
CBFA	2.71	2	1.35	.59	.59	2	.30	.13
Error	366.91	160	2.30		380.91	165	2.31	

	On-Level Classes				Teacher AVG CBFA			
Years of Exp		*M*	*SD*	*n*		*M*	*SD*	*n*
1 to 5		2.43	1.50	37		2.32	1.40	44
6 to 10		2.26	1.59	42		2.29	1.56	47
11 or more		2.02	1.54	137		2.05	1.48	170
Source	SS	df	MS	F	SS	df	MS	F
CBFA	5.70	2	2.85	1.19	3.75	2	1.87	.85
Error	508.13	213	2.39		568.71	258	2.20	

*p < .05

Differences in CBFA Usage Rates by End of Course Assessment

Results of the t-test analysis of CBFA usage rates by teachers that have end of course assessments (EOCT) found that there was a statistically significant difference at the .05 level in mean CBFA usage for teachers in the on-level courses. Teachers that predominately taught classes that had an end of course assessments were using CBFA with more frequency in the on-level academic courses than teachers that taught on-level courses that did not have end of course assessments. While there were no significant differences in CBFA usage for teachers that taught EOCT courses in their advanced/gifted classes, collaborative classes, or overall teacher average CBFA usage, a consistent pattern of higher usage rates for those teachers that had end of course assessments where noted for each of these class levels. As these differences were not significant, it is possible that for the teachers that participated in the study, the higher mean usage rates that were noted here may be due to chance, or due to the particular configuration of teachers in the study. Results of this analysis can be found in Table 8.

Table 8

T-test Results and Descriptive Statistics for Class Levels of CBFA Usage by Teachers with End of Course Assessments

	EOCT? No			EOCT? Yes			95% CI for Mean Difference		
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	df
Adv/Gifted	1.96	1.43	57	2.16	1.56	106	-.68, .30	-.79	161
On-Level	1.89	1.54	87	2.31	1.54	129	-.84, -.01	-2.00*	214
Collab.	2.12	1.49	57	2.32	1.53	111	-.68, .29	-.78	166
T. AVG	1.95	1.42	102	2.27	1.51	159	-.68, .06	-1.68	259

*p < .05

Differences in CBFA Usage Rates by Grade Level

Results of the t-test analysis of CBFA usage rates by teachers that taught either middle school or high school found that there was a statistically significant difference at the .01 level in mean CBFA usage rates for the advanced/gifted courses, the on-level courses, and for the teacher average CBFA usage rates for the grade level taught. Middle school teachers in advanced/gifted and on-level courses were using CBFA with a significantly higher frequency than the high school teachers in the same class levels. There was no significant difference in mean CBFA usage rates for middle school and high school teachers in collaborative classes. While not statistically significant, the mean CBFA usage for middle school teachers in collaborative classes was higher than the CBFA usage for high school teachers in collaborative classes as reported for the other class levels. This result could be due to chance given that the results were not significant for the particular teachers in the study. Results of this analysis can be found in Table 9.

Table 9

T-test Results and Descriptive Statistics for Class Levels of CBFA Usage by Teacher Grade Level

	Grade Level Middle			High			95% CI for Mean Difference		
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	df
Adv/Gifted	2.41	1.58	79	1.80	1.39	84	.15, 1.07	2.61*	161
On-Level	2.42	1.47	117	1.81	1.58	99	.20, 1.02	2.94*	214
Collab.	2.38	1.51	107	2.02	1.50	61	-.11, .84	1.52	166
T. AVG	2.45	1.47	130	1.84	1.44	131	.25, .96	3.37*	259

*p < .01

Differences in CBFA Usage Rates by Professional Learning

Results of the t-test analysis of CBFA usage rates by teachers that had professional learning on either instructional technology or formative assessment usage within the prior 12 months found that there was no statistically significant difference at the .05 level in mean CBFA usage rates for teachers that had professional learning in either instructional technology or formative assessment for advanced/gifted classes, for on-level classes, for collaborative classes or for teacher average CBFA usage. While significant differences for professional learning were not found, consistent patterns of mean CBFA usage did appear for professional learning on technology as well as formative assessment. Teachers in the study that reported professional learning on the use of technology reported higher mean CBFA usage rates for each of the three class levels as well as the teacher average CBFA usage rate. The results for professional learning on formative assessment usage indicated that teachers that reported professional learning on formative assessment were found to be using CBFA less often for each of the three class levels as well as the teacher average CBFA usage. Because these differences were not significant, it is possible that these patterns could be due to chance, the particular configuration of teachers in the study, or teacher interpretation of what activities constitute professional development. CBFA usage rates did not appear to be related to professional learning received by the teacher within the prior 12 months on the use of either instructional technology or formative assessment. Results of this analysis can be found in Table 10 and Table 11.

Table 10

T-test Results and Descriptive Statistics for Class Levels of CBFA Usage by Professional Learning on Technology

	Professional Learning on Technology								
	No			Yes			95% CI for Mean Difference		
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	df
Adv/Gifted	1.87	1.35	47	2.18	1.57	116	-.82, .21	-1.18	161
On-Level	1.96	1.54	72	2.23	1.55	144	-.71, .17	-1.22	214
Collab.	2.18	1.59	50	2.28	1.48	118	-.60, .41	-.39	166
T. AVG	1.99	1.46	83	2.21	1.49	178	-.61, .16	.26	259

*p < .05

Table 11

T-test Results and Descriptive Statistics for Class Levels of CBFA Usage by Professional Learning on Formative Assessment

	Professional Learning on Formative Assessment No			Yes			95% CI for Mean Difference		
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	df
Adv/Gifted	2.09	1.42	54	2.09	1.56	109	-.50, .50	.00	161
On-Level	2.26	1.51	76	2.07	1.57	140	-.24, .63	.87	214
Collab.	2.41	1.47	58	2.16	1.53	110	-.23, .73	1.02	166
T. AVG	2.28	1.42	90	2.07	1.52	171	-.17, .59	1.07	259

*p < .05

Differences in CBFA Usage Rates by Teacher Collaboration

Results of the t-test analysis of CBFA usage rates by teachers that have collaborated with other teachers on either instructional technology or formative assessment usage within the prior 30 days found that there was no statistically significant difference at the .05 level in mean CBFA usage rates for teachers that collaborated with other teachers in the past 30 days in either instructional technology or formative assessment for advanced/gifted classes, for on-level classes, for collaborative classes or for teacher average CBFA usage. While a significant difference was not found, a pattern of mean CBFA usage was noted for collaboration on technology as well as formative assessment. Results indicated that teachers that had collaborated with other teachers on technology in the prior 30 days had higher mean CBFA usage rates in their advanced/gifted classes, on-level classes, collaborative classes as well as the teacher average CBFA. For collaboration on formative assessment usage with the last 30 days, a similar pattern emerged with advanced/gifted, on-level, and teacher average CBFA all indicating higher mean CBFA usage for teachers that had collaborated on formative assessments. Because these differences in mean CBFA usage rates were not significant, it is possible that this pattern may be due to chance, the particular configuration of teachers participating in the study, or teacher interpretation of what constituted collaboration with other teachers on these topics. It is also noted that collaboration on these two topics appear to be commonplace in this district, with 81.6% reportedly collaborating on using instructional technology, and 90.8% of teachers reporting that they had collaborated with other teachers on formative assessment. Results of this analysis can be found in Table 12 and Table 13.

Table 12

T-test Results and Descriptive Statistics for Class Levels of CBFA Usage by Collaboration with Other Teachers on Technology

	Collaboration on Technology								
	No			Yes			95% CI for Mean Difference		
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	df
Adv/Gifted	2.06	1.28	34	2.10	1.57	129	-.62, .53	-.14	161
On-Level	1.76	1.38	42	2.23	1.57	174	-.99, .05	-1.77	214
Collab.	2.18	1.36	28	2.26	1.54	140	-.71, .54	-.27	166
T. AVG	1.98	1.33	48	2.18	1.52	213	-.67, .26	-.86	259

*p < .05

Table 13

T-test Results and Descriptive Statistics for Class Levels of CBFA Usage by Collaboration with Other Teachers on Formative Assessment

	Collaboration on Formative Assessment						95% CI for Mean Difference		
	No			Yes					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	df
Adv/Gifted	1.93	1.33	15	2.11	1.53	148	-.99, .64	-.43	161
On-Level	1.95	1.28	20	2.16	1.57	196	-.92, .51	-.57	214
Collab.	2.36	1.08	14	2.24	1.55	154	-.72, .95	.28	166
T. AVG	1.88	1.24	24	2.17	1.51	237	-.92, .26	-.93	259

*p < .05

Teacher Reported Reasons for Different Usage Rates

To further explore the differences in CBFA usage across class levels, an open ended question collected teacher responses on why they may have reported different usage rates for the different levels of classes that they taught. A total of 59 responses were submitted for this question. Of these 11 teachers indicated that they only taught one level of class during this semester or their responses could not be coded based on the information that was provided. The remaining 48 qualitative responses were coded by theme based on the reasons given. Five major themes emerged as reasons given: the needs of the class or individual students in the class, the need for repetitive practice for certain groups, behavioral concerns with using technology, a lack of instructional time, and a lack of applications to use with specific classes.

The Needs of the Class or Student. The most often cited reason for using CBFA at different rates for different class levels (advanced/gifted, on-level, or collaborative) was the needs of individual students or the need of the class as a whole. This reason was cited by 37.5% of teachers reporting. These teachers often referred to the need to differentiate the lesson, which led to varying needs for technology usage. For example, the following were some of the responses given:

"IEP in collaborative settings require assignments to be given via paper."

"The level of student, some more proficient than others, and motivations of the students for technology"

"My other two classes, one on-level and one collaborative are of the same content that is team planned and technology was not planned for that content area in the last five days"

"I have found that certain activities are better on paper or by having physical copies of things, and students get burned out on technology."

"The students are either at a different pace, or prepping for separate assignments, etc."

Repetitive Practice. The second most reported reason was the need for more repetitive practice with certain classes. This reason was cited by 27.1% of teachers reporting. These teachers stated that they used CBFA more often with lower ability level classes due to the need for more repetitive practice with those students as opposed to the more advanced students. Teachers viewed students in the more advanced classes as more motivated learners that could grasp concepts more quickly without the need for additional formative assessments or extrinsic motivation. A few of the comments illustrate this theme below:

"Collaborative classes need more practice than some of my on-level classes."

"I do use more with general level classes as it holds their attention more. In advanced courses there is an intrinsic need to complete the coursework regardless of interest level"

"I try to use formative assessments more frequently for my collaborative and general courses to make time to reteach/remediate when necessary."

"More review is needed in general and collaborative classes."

"My advance students do more independent explorations once I feel they have mastered a concept."

Behavioral Concerns. Behavioral concerns were found to be a theme reported by 14.6% of the respondents. Several of these teachers felt that the access to technology was a distraction for the lower level classes and thus teachers limited the use of technology. The following responses exemplify this concern:

"I have found that for my general and collab classes, technology use is not all it was supposed to be, and in many cases actually detrimental. Students with attention issues do MUCH better with paper tests, quizzes, and even assignments."

"Some of my collaborative students get easily distracted on computers, so I limit their access to it unless I am able to thoroughly walk around the room to observe."

"Some of my students struggle staying focused, even with technology. I have to mix it up so that classroom management stays a priority."

Lack of Time. Six teachers (12.6%) indicated that they did not have the time to use CBFA with their students. Three of these teachers reported that they did not have time to use it with advanced classes due to the faster pace of the coursework, and the other three stated that they did not have time to use it with lower level classes due to the longer time it takes to teach their lessons. The following two responses illustrate this:

"In my collab class, I run out of time because I have to take longer to explain a new concept or task."

"I have more time in my on-level class than I do for the advanced/gifted groups so I feel I can incorporate a larger variety of formative assessment techniques."

Lack of Applications. Finally, four teachers (8.3%) stated that with certain class levels, there were limited CBFA applications that were created for the classes that they taught. Teachers cited the lack of pre-made resources for upper-level courses as the predominate reason. The following responses highlight this:

"AP Calculus, there are not many readily available (quizizz is okay for some but not Calculus BC). I do not have time to make them. I like to use materials that I find readily available."

"The availability of technology resources such as IXL, and USATESTPREP are not available for all content areas."

"Different assessments in different level classes, different instructional materials being used; resources available for paid sources, only Yearlong has access to IXL."

Teacher Comfort with Technology

The third research question was: To what degree does teacher comfort with technology correlate to their frequency of use of CBFA in a one-to-one computing setting? To answer this question and research questions four, five, and six, the mean composite score of the questions related to the construct in each research question were calculated and Pearson r was used to correlate the mean usage rates across the three class levels and the teacher average CBFA usage rate to each of the four constructs. Results indicated that teacher comfort with technology was significantly correlated ($p < .01$) to CBFA usage for all three levels of classes and for teacher average CBFA usage. Results were very consistent across all four measures with advanced/gifted usage ($M = 2.09$), on-level usage ($M = 2.14$), and teacher average usage ($M = 2.14$) all correlating at $r = .27$, while collaborative usage ($M = 2.25$) was slightly higher at $r = .31$. This indicated that as teacher comfort with technology increased, teachers were using CBFA with more frequency in all levels of classes. A correlation matrix is presented in Table 14 that reports this data.

Perceived Benefit of Technology

The fourth research question asked: To what degree does a teacher's perceived benefit of using instructional technology in the classroom correlate to their frequency of use of CBFA in a one-to-one computing setting? Results reported in Table 14 indicated that the teacher perceived benefit of using instructional technology was significantly correlated ($p < .01$) to CBFA usage for all three levels of classes and for teacher average CBFA usage. Pearson r correlations were again very consistent across all four measures with advanced/gifted usage $r = .31$ ($M = 2.09$), on-level usage $r = .32$ ($M = 2.14$), and teacher average usage $r = .29$ ($M = 2.14$), while collaborative usage ($M = 2.25$) slightly lower at $r = .26$. This indicated that as a teacher's belief in the benefit of using technology in their classroom increased, teachers were using CBFA with greater frequency in all levels of classes.

Technology Support and Vision

The fifth research question asked: To what degree does teacher-perceived technology support and vision correlate to their frequency of use of CBFA in a one-to-one computing setting? Results reported in Table 14 indicated no significant correlation among this construct and teacher use of CBFA in any level of class. To further explore possible relationships with CBFA usage and the five individual items in this construct, Pearson r correlation was conducted to determine if there were significant relationships with any of the five items for any of the class levels or the teacher average CBFA usage. Results reported in Table 15 indicated no significant relationships with any of the five items for any of the class levels or the teacher average CBFA usage. This result implied that providing teachers with instructional technology support and establishing a technology usage vision across the school is unrelated to a variation in CBFA usage rates.

Teacher Autonomy

The sixth and final research question asked: To what degree does a teacher's level of perceived autonomy correlate to their frequency of use of CBFA in a one-to-one computing setting? Results reported in Table 14 indicated no significant correlation among this construct and teacher use of CBFA in any level of class, or the teacher average use of CBFA. This result implied that providing teachers with increased levels of autonomy does not correlate to a higher frequency of CBFA usage. While there was not a significant relationship between CBFA usage and the teacher autonomy construct as a whole, an exploratory correlational analysis of the seven items in the construct was conducted to determine if any of the items measuring autonomy were significantly related to CBFA usage rates.

Each of the component questions in the construct for teacher perceived autonomy was correlated using Pearson r to the three levels of classes and the teacher average CBFA usage rates. Results indicated that there are two significant correlations among these questions and the CBFA usage rates, specifically questions 14 and 19. Question 14 stated, "I am able to select assignments for my students on my own." This question was significantly positively correlated to the CBFA usage rate for collaborative classes at the .05 level. This result implies that when teachers felt more strongly that they could select assignments on their own, their CBFA usage in their collaborative classes increased also. No significant relationship was found for the other levels of classes, or for teacher average CBFA usage. Question 19 stated, "I am free to select the teaching methods and strategies that seem most appropriate to me." For this question, there were significant negative correlations for all levels as well as for teacher average CBFA usage. For advanced/gifted, on-level, and collaborative, this correlation was significant at the .05 level, and for the teacher average CBFA usage, it was significant at the .01 level. This result implied that as teachers felt more autonomy to select their teaching methods and strategies, they were using CBFA with less frequency. Results of this analysis can be found in Table 16.

Table 14

Correlation and Descriptive Statistics for Frequency of CBFA Usage Across Class Types, Teacher Average CBFA Usage, and Constructs

	1	2	3	4	5	6	7	8
1. Advanced/gifted	--							
2. On-level	.92**	--						
3. Collaborative	.91**	.94**	--					
4. Teacher average	.97**	.98**	.98**	--				
5. Comfort with technology	.27**	.27**	.31**	.27**	--			
6. Perceived benefit of tech.	.31**	.32**	.26**	.29**	.66**	--		
7. Tech. support and vision	.06	.00	-.03	.00	.24**	.38**	--	
8. Autonomy	-.01	-.03	.02	-.02	.35**	.34**	.36**	--
M	2.09	2.14	2.25	2.14	3.14	3.26	3.08	3.44
SD	1.51	1.55	1.51	1.48	.54	.48	.48	.45

Note. Means for advanced/gifted, on-level, collaborative, and teacher average represent the reported frequency of CBFA usage in each category. Means for each of the four constructs represent the composite score for each.
$n = 261$
$^{**}p < .01$.

Table 15

Correlation and Descriptive Statistics for Technology Vision and Support Component Questions and CBFA Usage Rates

	1	2	3	4	Q12	Q15	Q20	Q31	Q32
1. Advanced/gifted	--								
2. On-level	.92**	--							
3. Collaborative	.91**	.94**	--						
4. Teacher average	.97**	.98**	.98**	--					
Q12	-.02	-.02	-.01	-.03	--				
Q15	.06	.00	-.05	-.01	.48**	--			
Q20	.10	.10	.04	.11	.41**	.38**	--		
Q31	.06	-.03	-.06	.00	.26**	.53**	.23**	--	
Q32	.02	-.05	-.05	-.06	.38**	.40**	.40**	.30**	--
M	2.09	2.14	2.25	2.14	3.68	3.48	3.44	3.18	3.40
SD	1.51	1.55	1.51	1.48	.49	.62	.61	.70	.64

Note. Means for advanced/gifted, on-level, collaborative, and teacher average represent the reported frequency of CBFA usage in each category.
$n = 261$
$^{**}p < .01$.

Table 16

Correlation and Descriptive Statistics for Teacher Autonomy Component Questions and CBFA Usage Rates

	1	2	3	4	Q14	Q19	Q23	Q27	Q28	Q35
1. Advanced/gifted	--									
2. On-level	.92**	--								
3. Collaborative	.91**	.94**	--							
4. Teacher average	.97**	.98**	.98**	--						
Q14	.09	.09	.19*	.10	--					
Q19	-.16*	-.16*	-.16*	-.17**	.28	--				
Q23	-.07	-.06	-.04	-.06	.30	.73	--			
Q27	.03	-.01	.05	.02	.27	.53	.54	--		
Q28	-.05	-.07	-.05	-.07	.27	.61	.61	.58	--	
Q35	.14	.10	.14	.10	.36	.56	.56	.46	.52	--
M	2.09	2.14	2.25	2.14	3.68	3.48	3.44	3.18	3.40	3.51
SD	1.51	1.55	1.51	1.48	.49	.62	.61	.70	.64	.53

Note. Means for advanced/gifted, on-level, collaborative, and teacher average represent the frequency of CBFA usage in each class level category.
n = 261
*p < .05.
**p < .01.

Summary of Findings

In this study, a questionnaire was used to collect information on the CBFA practices of middle school and high school academic teachers in a Georgia suburban school district that operated a one-to-one Chromebook program. Two hundred and sixty-one teachers took part in the study and provided information on which CBFA applications they were using with their students and how often they were using them in classes of students with different ability levels. Teachers also reported on their perceptions of their own comfort with technology, their belief in the benefit of using technology, their perceived level of technology support and vision in their school, and the level of teacher autonomy that they perceived. After analyzing the responses and compiling results in frequency tables, conducting one-way ANOVAs, and utilizing Pearson r correlations, several themes emerged.

1. Academic teachers in this district at both the high school and middle school levels across all four academic areas were using a wide variety of CBFA applications with their students.
2. There were significant differences in CBFA usage for the following demographic variables: subject taught, grade level taught, and for teachers that have end of course assessments.
3. Teachers were deciding to use CBFA based on the differentiated needs of their students, teacher beliefs related to student ability level, the ability of technology to motivate students, and the time for teachers to use CBFA.
4. There was a significant positive statistical relationship between teacher CBFA usage rates and the teacher's comfort with technology.
5. There was a significant positive statistical relationship between teacher CBFA usage rates across all levels of classes and the teacher's belief in the benefit of instructional technology.
6. There was a significant positive statistical relationship between teacher autonomy to select their own assignments for their students and the frequency of CBFA usage in collaborative classes.
7. There was a significant negative statistical relationship between teacher autonomy to select teaching methods and strategies and their use of CBFA across all class levels with their students.

The overview of the findings of this study, the implications, limitations, and recommendations for further research will be discussed in chapter five.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

The purpose of this correlational study was to investigate the Computer-based Formative Assessment (CBFA) practices of core academic teachers within a one-to-one computing environment in one mid-sized suburban Georgia school district to better understand the relationships between teacher usage rates of CBFA in their classrooms and their beliefs and attitudes toward technology. The following research questions guided this study:

1. Which CBFA applications are middle school and high school academic teachers in one mid-sized, suburban Georgia school district using in a one-to-one networked environment to formatively assess student learning?
2. Are there differences in average CBFA usage rates across teacher and course-specific factors in a one-to-one computing setting?
3. To what degree does teacher comfort with technology correlate to their frequency of use of CBFA in a one-to-one computing setting?
4. To what degree does a teacher’s perceived benefit of using instructional technology in the classroom correlate to their frequency of use of CBFA in a one-to-one computing setting?
5. To what degree does teacher perceived technology support and vision correlate to their frequency of use of CBFA in a one-to-one computing setting?
6. To what degree does a teacher’s level of perceived autonomy correlate to their frequency of use of CBFA in a one-to-one computing setting?

This chapter consists of five sections. The first section will discuss the major findings of the study and compare these findings with those of existing literature on the use of instructional technology and formative assessment by teachers. The second section will discuss the limitations involved in this study. The third section will discuss the implications for practice resulting from this research. The fourth section will review recommendations for future research studies. The fifth and final section will provide closing thoughts and conclusions that stem from this research study.

Discussion

There were several major findings of this study and each will be discussed in this section. The study found that in this one-to-one computing setting, academic teachers at the middle school and high school levels were using a variety of CBFA applications. There were significant differences in the frequency that teachers were using CBFA with their students in different class levels (advanced/gifted, on-level, collaborative) based on student need and teacher beliefs. Several factors appear to have been related to teacher choice to use CBFA more frequently with their students at different class levels including: the subject that they taught, whether or not the teacher's classes had an end of course assessment, and the grade level at which the teacher taught. Additionally, teacher comfort with technology, teacher beliefs about the benefits of instructional technology, and teacher autonomy were significantly related to the rate of their CBFA usage.

Widespread Use of CBFA Applications

There are an ever growing number of interactive Web 2.0 tools that are available for teachers to use with their students (Bower, 2016) and this study corroborated these varied uses of technology. Results of prior research has shown that when access to technology is removed as a barrier, student-centered instructional changes have been shown to occur in the classroom which includes teachers using the technology to formatively assess student learning (Varier et al., 2017). According to the authors, ease with which teachers could formatively assess student learning, provide instant feedback as well as motivate students, were cited as primary reasons for the change in formative assessment practice in their study. Consistent with these findings, an overwhelming majority of teachers from all subjects at the high school and middle school levels in this district were found to be regularly using a wide variety of CBFA applications with their students. The three most commonly reported CBFA applications used by teachers in the study were Google Forms Quiz used by 77% of the teachers, followed by Kahoot! at 61%, and then Quizlet Live at 51% using this application. The widespread use of CBFA observed in this study is likely due to the ease of access to the technology as well as the ease of use of the applications. Each student was provided with their own computing device and thus access to the computing devices had been eliminated as a barrier. Additionally, the three most cited applications were applications that were available for teachers and students at no cost and required teachers to create their own content in simple user-friendly interfaces. Thus, the ease of access and the control over content may be important factors when teachers are choosing CBFA applications to use with their students.

Differences in CBFA Usage

In total, eight demographic factors were investigated to look for differences in CBFA usage rates across three class levels (advanced/gifted, on-level, collaborative) and teacher overall average CBFA use. While patterns of mean CBFA usage were observed for the following factors: years of experience, professional development or collaboration in formative assessment and/or technology, no significant differences in CBFA usage where found for these factors. These results were not consistent with prior research that found differences in either formative assessment usage or technology usage for years of experience (Blackwell et al., 2014), professional development (Hollingworth, 2012) or collaboration (Birenbaum et al., 2011). These results imply that in this one-to-one setting with access to the technology so readily available, all teachers regardless of experience, professional learning or collaboration were using CBFA at similar rates. Significant differences were found for CBFA usage rates for the subjects taught, teachers with end of course assessments, and for the grade level of the teachers. These results were consistent with prior research findings for subject differences (Hsu, 2016; Keane, 2012), end of course assessments (Ertmer et al., 2012), and grade levels (Ruggerio & Mong, 2015).

Subject Taught

Different technology usage patterns for different subjects were noted in two of the studies referenced (Hsu, 2016; Keane, 2012). While these studies simply noted that different subjects used technology for different purposes, the current study sought to quantify any statistical differences among the four academic subjects in their frequency of use of technology for the purpose of providing CBFA to their students in difference class levels. The mean CBFA teacher average usage rates for each subject indicated that English teachers had the highest average usage rate ($M = 2.46$), followed by social studies teachers ($M = 2.28$), then science teachers ($M = 2.14$), and finally mathematics teachers at ($M = 1.78$). Although the mean CBFA usage rates for mathematics teachers were lower than the other three subjects, a statistically significant difference was found only between English and mathematics teachers. Results indicated that mathematics teachers were statistically less likely to use CBFA with their students than English teachers. This result is consistent with findings from prior research indicating that teachers were most likely to use technology during English instruction (Hsu, 2016). One possible explanation for this outcome could be related to the ease of use of the CBFA applications to create content for English classes versus content for mathematics classes. Assessments in English classes can generally be created using text-based questions, whereas in mathematics classes the questions often require special symbols and formatting requirements. While some teachers had access to paid content-specific applications, the most often used applications were free-to-use versus paid subscriptions. The free-to-use applications generally require teachers to create their own content, which would be more time-consuming, especially for mathematics teachers. The difficulty to create mathematical questions and the lack of access to paid content-specific applications may have contributed to the less frequent use of the CBFA applications.

End of Course Assessment

Teachers have been shown to be less likely to use technology in their classrooms when they are uncertain of the effectiveness of the technology to ensure favorable outcomes (Ertmer et al., 2012). In a study that focused on formative assessment usage, researchers found that teachers tended to use formative assessment less often in classes that had an end of course test due to constraints on their time to cover material that was going to be on the test (Box et al., 2015). Results of the current study found that there is a statistical difference in the CBFA usage rates in on-level courses when the teacher predominately teaches classes that have end of course (EOC) assessments. Contrary to the findings of Box et al., the teachers in the current study that have EOCs are using CBFA significantly more often ($M = 2.31$) in on-level courses than teachers that do not predominately teach these types of classes ($M = 1.89$). This implies that teachers in on-level courses that primarily teach classes with end of course assessments tend to value the outcome of the CBFA to provide students with favorable academic outcomes, which would be consist with the findings of Ertmer et al. (2012). The findings of the current study are not consistent with the research from Box et al. (2015) that found teachers used formative assessment less often when they were worried about an end of course test and their time to cover the material. The difference in research results may be due to the ease of use of the CBFA applications in creating the assessments and returning individual results to the students. The time to conduct the formative assessment is thus greatly reduced when using CBFA.

Grade Level Differences

Despite a thorough search for research studies that investigated the differences in technology usage or formative assessment usage between the middle school and high school levels, only one study was found that investigated technology usage patterns across elementary, middle, and high school levels. This study, conducted by Ruggerio and Mong (2015), found that while technology usage was pervasive at all levels, there were differences in the types of uses of technology found between the levels. Specifically, that high school teachers primarily used technology for presentations, whereas elementary teachers primarily used the technology for interactive tools. Differences for middles school teachers and high school teachers were not referenced in the study. The current study sought to fill this gap in the research by investigating the differences in CBFA usage across middle school and high school levels. Results of this study indicated that middle school teachers are using CBFA significantly more often with their students overall and this difference is also present in their advanced/gifted and on-level courses. There was however, no significant difference in usage in collaborative classes. Based on the qualitative responses given by the teachers in this study, there were two proposed reasons for the differences found in CBFA usage rates between these middle school and high school teachers. The first may be due to the differences in course lengths between the middle school and high school courses. All of the middle school classes were year-long, taught from August through May, while the overwhelming majority of the high school classes were semester long. With the compressed schedule at the high school level, it is possible that teachers did not feel that they had time to incorporate CBFA as often with their students. The second reason may relate to the teacher beliefs on the motivational benefit of frequent CBFA usage with their students. As the use of instructional technology has been shown to be an academic motivator for most students, teachers at the middle school level may be using CBFA more often with their students to maintain interest and motivation, while teachers of the older students at the high school level may not feel the need to use these motivational tools with as much frequency.

Teacher Technology Comfort and Beliefs

Several studies have established a clear connection between teacher comfort with technology and/or teacher belief in the benefit of instructional technology and their increased use of technology in their classrooms (Ertmer et al., 2012; Keane, 2012; Kopcha, 2012; MacCullum & Jeffrey, 2014; Minshew & Andersson, 2015; Sadaf et al., 2016). In fact, even when significant external barriers exist such as limited access to technology, hardware limitations, or a lack of technology support, teachers that have a high-level of comfort with technology and have belief in the benefit of technology to enhance student learning will work through these barriers in order to use the technology with their students (Ertmer et al., 2012). The findings of this study confirm these prior studies and found a significant positive correlation between teacher belief in the benefit of instructional technology and the frequency of CBFA usage in classrooms of all class levels. Teachers that have comfort with technology and/or a belief that using technology is beneficial to student learning, tend to be using CBFA more often with their students.

Teacher Autonomy

Prior research investigating formative assessment usage found that when teachers feel more autonomy they tend to use higher quality formative assessment practices (Birenbaum et al., 2011). Additionally, research has shown that when teachers feel that they have more autonomy to select instructional technology applications on their own, they tend to use these applications more often than teachers who were not able to choose their own applications (Minshew & Andersson, 2015). For the general teacher autonomy construct used for this study, no significant correlations between autonomy and CBFA usage were found. However, by correlating each of the individual autonomy component questions to CBFA usage, two significant findings were noted. Results of the current research found that in collaborative classes, a statistically significant positive relationship was found between teacher autonomy to select assignments for their students and their CBFA usage. This is consistent with the research from Minshew and Anderson (2015), which found that teachers that felt more autonomy to select applications to use with their students tended to use the applications more often. Conversely, the current study found that when teachers felt that they had increased autonomy to select teaching methods and strategies, a significant negative relationship was found between the frequencies of use of CBFA for all levels of classes. This last finding seems contrary to prior research from Birenbaum et al (2011) and Minshew and Andersson (2015); however, Minshew and Andersson noted that many of the teachers in their study, "would integrate technology to fill a demand rather than enhance instruction" (p. 358), indicating that administrative demands often drove teachers to incorporate technology in instances when they may not have chosen to do so. Their findings are consistent with the current study and would indicate that some level of administrative mandate may be needed to alter teaching methods and strategies related to using CBFA, especially at the early stages of technology integration.

Limitations

Limitations in a research study are any elements of the study that may negatively impact the ability to generalize the results and which the researcher has little control (Roberts, 2010). This study was limited to a single Georgia school district and exclusively focused on core academic teachers at the six middle schools and three high schools in this district. For this reason, the generalizability of the results may not be possible and may not reflect practices at the elementary level or the practices of teachers in other school districts. While the sample size for this study was acceptable at a rate of 63.0% and every effort was made to collect responses from all teachers in the target population, it is recognized that utilizing a sample of teachers that voluntarily opted to complete the survey may not fully represent all teachers in the population. The nature of the study was expressed in the invitation to join the study and it is possible that teachers with little interest in instructional technology may have not participated at the same rate as other teachers who were more interested in instructional technology.

Additionally, the data collected represented the CBFA practices of participating teachers over a one-week time interval during the school year and the professional learning and collaborative practices over the prior 12 months and 30 days respectively. This provided the researcher with a snapshot of CBFA usage, professional learning, and collaboration during only part of the academic year. This may not reflect everyday usage or practices at other times during the school year within this district.

Another possible limitation of the study is the subjective nature of some of the questions on the questionnaire, specifically concerning professional learning and collaboration. It is acknowledged that teachers may have interpreted what constitutes a professional learning activity or collaboration with other teachers in different ways. The instrument used for the study did not explicitly define these terms. This may have led to an inaccurate reporting of these activities. Finally, as this study relied on a self-report questionnaire to collect data, this study must assume the answers provided reflect actual classroom practices, and beliefs of the participants.

Implications for Practice

Formative assessment usage and instructional technology usage each face unique barriers in the classroom. Researchers have found that professional knowledge on the use of formative assessment and instructional technology is instrumental to both practices (Andersson & Palm, 2017; Kopcha, 2012). The internal beliefs of the teachers themselves seem to play the most significant role in the use of these practices in the classroom and have been documented in several studies (Box et al., 2015; Ertmer, 1999; Hew & Brsuh, 2006; Minshew & Andersson, 2015). The findings of this study reinforce the understanding of teacher beliefs in shaping the frequency of CBFA usage and can assist teachers and school leaders in developing support systems to enhance this instructional practice via professional learning. Based on the results of the current study several implications of practice are noted below.

This study found evidence that the use of CBFA is widespread among the teachers in the study and a variety of applications were being utilized by teachers. Additionally, collaboration with other teachers on instructional technology and formative assessment was also pervasive in this district. In this one-to-one computer to student ratio environment, and based on these findings, building leaders should encourage teacher collaboration in the area of formative assessment and instructional technology.

MacCallum and Jeffrey (2014) found that the most significant barriers to teacher's use of instructional technology were their belief in the value of the technology to ensure favorable instructional outcomes and their comfort with technology. The current study confirmed this finding by determining that there was a significant positive relationship between CBFA usage rates and their comfort with technology as well as their positive belief in instructional technology. School leaders desiring an increase in the use of CBFA should seek methods for increasing teacher comfort with technology and explicitly detailing the benefit of using the technology. Teachers need to not only have the ability to use the technology, but they must also value the use of the technology. Professional learning and collaboration on the use of CBFA can aide in achieving both of these goals.

Minshew and Andersson (2015) indicated that professional learning in the area of technology needed to be subject-specific and should ensure that teachers are able to make a connection with the use of technology and their classroom practice. In this current study, significant differences in CBFA usage rates were found among teachers between different subject areas, different grade-levels, and the presence of an end of course assessments. These findings support the notion that CBFA professional learning for teachers should be subject-specific related to the needs of the specific target audience and should establish a clear connection between the use of the technology and the academic goals of the teacher's courses.

Teachers in the current study also indicated that they used CBFA at different rates depending on the academic level of the students in the classes. Several teachers indicated that they used CBFA more often with less advanced classes in the belief that more advanced students did not need as much practice and were more intrinsically motivated and therefore did not need to use CBFA as often. Conversely, some teachers also reported that they used CBFA less often with their collaborative students due to behavioral concerns from lack of attention and off task behavior while using CBFA with them. School leaders, specifically building leaders should provide specific guidance on the frequency of the use of CBFA with students in all classes regardless of ability level. The use of frequent formative assessments has been shown to benefit all students (Black and Wiliam, 1998a) and teachers may be missing an opportunity to enhance student learning for their more advanced students by using CBFA less often with those students.

Teachers should also be encouraged to alternate the type and frequency of use of CBFA applications that they use with their students, especially in collaborative classes. Varier et al. (2017) noted that the novelty of a technology seemed to be a significant motivator with students and increased engagement. Teachers run the risk of technology burn out if they continue to use the same applications repeatedly with their students. This is another area where subject-specific targeted teacher collaboration and professional learning can assist teachers.

Birenbaum et al. (2011) found that when teachers were given more autonomy, they generally demonstrated a higher quality formative assessment practice. Similarly, Minshew and Andersson (2015) found that when teachers in a one-to-one computing environment had more autonomy to select the applications they used with students in their classroom that they tended to use those applications more often. The findings of this current study also found that when teachers expressed more autonomy in selecting assignments, they used CBFA at higher rates. However, when autonomy was examined from the viewpoint of selecting teaching methods and strategies, teachers with more autonomy in this area used CBFA less frequently. These results suggest two recommendations for school leaders. First, allow teachers to have a voice in the selection of CBFA applications that they use with their students, and second, some level of administrative directive to use CBFA applications with students may be needed to encourage teachers to use the instructional tool with more frequency. Building leaders may be advised to set the expectation of CBFA use while allowing teachers to determine which applications that they will use in their classroom.

Recommendations for Future Research

This research study has confirmed many recent findings related to formative assessment usage and instructional technology usage specifically to CBFA in one-to-one computing environments. This study has added to the growing body of research on CBFA and the factors that influence teacher's use of CBFA with students of different ability levels in a one-to-one technology setting. Due to the limitations and constraints of the current research study, this researcher makes the following recommendations for future research.

1. This research focused on one suburban Georgia school district. The study could be replicated and expanded to additional school districts across the state or in other states across the United States that are using personal computing devices in a one-to-one ratio. This would greatly increase the ability to generalize the results.
2. This research focused exclusively on the CBFA usage rates of teachers over a one-week period of time. Future research could expand on this by extending the data collection period over several weeks or months to get a more accurate picture of CBFA usage over the course of the year. This would also allow researchers to examine differences in usage rates at different points in the school-year.
3. This research found unique patterns of CBFA usage and teacher beliefs concerning students in collaborative settings. Mean usage rates were the highest in these classes and teachers reported that they felt the need to increase the use of CBFA in these classes for more repetitive formative assessment. Several teachers also reported that they often limited technology use in these classes because they felt that students were more distracted when using technology. Future research could focus exclusively on collaborative classes to more fully explore the unique barriers to CBFA usage in this class setting.
4. This research focused exclusively on CBFA usage rates as they relate to teacher and class factors. Future research could examine the effectiveness of increased CBFA

usage to improve student achievement across the three class levels (advanced/gifted, on-level, collaborative) and using the same teacher and class factors.

5. Finally, this research was solely interested in formative assessments that were conducted via computer or other technology. Future research could replicate the study by including non-technology means to formatively assess student learning. Researchers could then get a more accurate picture of how often teachers are using formative assessment in their classes and determine if similar patterns of use will emerge over teacher and class factors.

Conclusion

This research has confirmed prior research findings and found a statistically significant positive correlation between CBFA usage rates and teacher comfort with technology as well as CBFA usage rates and teacher perceived benefit of using technology. This research study has also illustrated that teacher beliefs about the needs of their students are impacting their decisions to use CBFA with their students. Significant differences in CBFA usage rates were found between different subjects, class ability levels, grade levels, and for teachers that have state-mandated end of course assessments. These findings support the idea that differences in teacher beliefs about student learning are related to the frequency of computer-based formative assessments usage by teachers. As building level leaders plan for instructional technology professional development, awareness of these differences in CBFA usage can be instrumental in crafting targeted learning which can address the different attitudes and beliefs of their teachers toward instructional technology.

In all subjects in both middle school and high school, a majority of teachers reported that they are using CBFA with their students. While the frequency of use has been shown to be dependent on several different factors, teachers in all subject areas are using a wide variety of applications with their students. As new applications become available, it is important for teachers and leaders to continue to research and learn about these applications. While several studies have shown that when students use one-to-one technology, they are generally more motivated and engaged (Fleischer, 2017; Lindsay, 2016; Roschelle et al., 2004; Varier et al., 2017), and this engagement has been linked to the novelty of the technology (Varier et al.,2017). With increased use of the same CBFA applications, there is the risk that this novelty will wane resulting in less interest from the students. Research findings from this study revealed that several teachers indicated that they were changing technology usage patterns due to student inattention when using CBFA. This implies that teachers should continually seek out new CBFA applications and ways to incorporate them into their classrooms in order to avoid student application fatigue. The findings of this study may assist teachers in learning about applications that other teachers are using that may be interesting and useful to their students.

In one-to-one computing environments, access to technology and online applications is no longer a barrier to using CBFA tools with students. The results of this research study have shown significant positive relationships between CBFA usage rates and the teacher's comfort with technology, and their belief about the usefulness of technology. This study also found a statistically significant negative relationship with teacher autonomy to select teaching methods and strategies and CBFA usage rates. For school leaders interested in increasing CBFA usage, this may imply that less teacher autonomy in using CBFA applications may be needed until teacher beliefs and attitudes about CBFA can be positively influenced through targeted professional development.

Computer-based formative assessments have the potential to increase student motivation and achievement if teachers are using them with enough frequency. The findings of this study indicated that in a one-to-one computing environment where access to technology was no longer a barrier, teacher beliefs and attitudes toward technology were influencing CBFA usage patterns. School leaders with an understanding of these beliefs can effectively support the individual needs of their teachers' use of this powerful instructional tool.

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APPENDICES

APPENDIX A

GEORGIA TKES PERFORMANCE STANDARDS

Standard 1: Professional Knowledge

Standard 2: Instructional Planning

Standard 3: Instructional Strategies

Standard 4: Differentiated Instruction

Standard 5: Assessment Strategies

Standard 6: Assessment Uses

Standard 7: Positive Learning Environment

Standard 8: Academically Challenging Environment

Standard 9: Professionalism

Standard 10: Communication

APPENDIX B

WEB 2.0 FORMATIVE ASSESSMENT APPLICATIONS

Name of Web 2.0 Tool	Description	Web address
Plickers	An application that uses printed numbered cards with letter choices, A, B, C, and D. When teachers pose a question, each student holds up their response card with their choice at the top. The teacher uses a handheld device with a camera to scan the room to capture responses. The teacher can then visit the website to view responses.	https://plickers.com
Poll Everywhere	The teacher creates an online account. Students visit the teacher site via a mobile device. Questions are posed by the teacher during class and students type in responses in multiple choice or free response form. The teacher can view results instantly.	https://polleverywhere.com
Nearpod	The teacher creates a slideshow and inserts questions. Students answer questions as the slideshow is presented. The pacing can be student-led or teacher-led.	https://nearpod.com
Formative	The teacher can create digital assignments. Students answer questions as multiple choice, free response, true-false, open-ended, or drawings. Teachers can see results instantly as the students progress and provide feedback.	goformative.com
Quizizz	Students play live quiz games. Each student's computer displays the questions and choices. A leader board keeps track of student progress compared to the rest of the class.	quizizz.com
Quizlet Live	A team-based question and answer game. Students work in teams to answer questions and compete against other teams in the class. Teamwork is required as no one student can see all of the questions. A running leader board presented to the class shows the team progress toward winning the game.	quizlet.com

APPENDIX C

SURVEY INSTRUMENT

Directions
All individual responses in this questionnaire will remain anonymous. Please answer each question as accurately as possible. The results of this questionnaire may be used to improve practices in our district related to instructional technology.

The questionnaire consists of 38 questions and should take approximately 10 minutes.

Computer-Based Formative Assessment (CBFA) refers to any classroom use of technology to collect information from students. Immediate feedback is given to the students on the quality of the information they provided, either by the teacher, another student, or by a computer program.

Some examples include: *CK12, Clickers, Formative, GCA Item Bank, Google Forms Quiz, IXL, Kahoot, Quizlet Live, Quizizz, NearPod, No Red Ink, Plickers, Prodigy, Poll Everywhere, Socrative, USATESTPREP*, there are others that you may be using….

For questions 1 - 3, please answer NA if you do not currently teach this type of class.

1. For your advanced or gifted classes: In the last 5 class days, on how many days did you use a CBFA with these classes? (NA, 0, 1, 2, 3, 4, 5)
2. For your collaborative classes: In the last 5 class days, on how many days did you use a CBFA with these classes? (NA, 0, 1, 2, 3, 4, 5)
3. For your on-level classes: In the last 5 class days, on how many days did you use a CBFA with these classes? (NA, 0, 1, 2, 3, 4, 5)
4. How many years of teaching experience do you have including this year? (Richards, 2005) (1 - 5 years, 6 – 10 years, >11 years)
5. What subject do you primarily teach? (English, Science, Math, SS)
6. What is the grade level that you primarily teach? (MS, HS)
7. Have you been provided any training or professional development on the use of formative assessments in the last 12 months? (Yes/No)
8. Have you been provided any training or professional development in the use of instructional technology in the last 12 months? (Yes/No)
9. During the last 30 days, have you discussed with other teachers, any methods that one could use to formatively assess student learning? (Yes/No)
10. During the last 30 days, have you discussed with other teachers how to use instructional technology in the classroom? (Yes/No)
11. Do you currently teach at least two classes that have a state-mandated standardized test at the end of the course? (Yes/No)

For the next set of questions, select the response that best fits your level of agreement to the given statement.
Strongly Agree = 4, Agree = 3, Disagree = 2, Strongly Disagree = 1

Construct 1: Comfort with Technology (Reinhart & Banister, 2009)

13. I feel comfortable about my ability to work with instructional technologies.
16. Learning new technologies is confusing for me. (Reversed)
18. I get excited when I am able to show my students a new technology application or tool.
21. I get anxious when using new technologies because I may not know what to do if something goes wrong. (Reversed)
22. I enjoy finding new ways that my students and I can use technology in the classroom.
26. I am confident with my ability to troubleshoot when problems arise while using technology.
29. Learning new technologies that I can use in the classroom is important to me.
30. I am confident in trying to learn new technologies on my own.

Construct 2: Perceived Benefit in using Technology in the Classroom (Reinhart & Banister, 2009)

17. Computer technology allows me to create materials that enhance my teaching.
24. Computer technologies help me be better organized in my classroom.
25. My students get excited when they use technology in the learning process.
33. Technology can be an effective learning tool for students.
34. Using technology to communicate with students allows me to be more effective in my job.

Construct 3: Technology Vision and Support (Reinhart & Banister, 2009)

12. A vision for technology use in our school is clearly communicated to the faculty.
15. Curriculum support is available in my building to assist with technology integration ideas.
20. My building principal encourages faculty to integrate technology in the classroom.
31. Technology support is available in my building to assist with troubleshooting.
32. My colleagues are committed to integrating technology in the classroom.

Construct 4: Teacher Autonomy (Vangrieken et al., 2017)

14. I am able to select assignments for my students on my own.
19. I am free to select the teaching methods and strategies that seem most appropriate to me.
23. I have the freedom to design and prepare lessons in my own way.
27. I am allowed to assess my students as I want.
28. I have the freedom to use and adapt classroom management strategies in a way that seems most appropriate to me.
35. I have the freedom to use Chromebooks and other technology in a flexible way in my lessons.

36. Select all of the CBFA applications that you have used with your students during class in the <u>last 30 days</u>. Select from this list.
CK12, *Clickers*, *Formative*, *GCA Item Bank*, *Google Forms Quiz, IXL, Kahoot, Quizlet Live, Quizizz, NearPod, Playposit, Plickers, Poll Everywhere, Prodigy, Socrative, USATESTPREP, None used in the last 30 days*.

37. List all other CBFA not listed in 36, which you have used with your students in class in the last 30 days. Please separate each entry with a comma.

38. If you reported in Q1, Q2, and Q3 that you are using CBFA at different rates over the last 5 days for different class levels (advance/gifted, on-level, or collaborative classes), please describe the reasons for the different usage rates.

APPENDIX D

SURVEY INSTRUMENT ANALYSIS

Item(s)		Research	Research Question(s)
1	Adv/Gifted CBFA usage	Blackwell et al., 2014; Missett et al., 2014; Sheard & Chambers, 2014	2
2	Collab CBFA usage	Blackwell et al., 2014; Koedinger et al., 2010; Missett et al., 2014; Sheard & Chambers, 2014	2
3	On-level CBFA usage	Blackwell et al., 2014; Box et al., 2015; Missett et al., 2014; Sheard & Chambers, 2014	2
4	Years of experience	Blackwell et al., 2014; Box et al., 2015; Hsu, 2016	2
5	Subject	Hsu, 2016; Zheng et al., 2016	2
6	Grade level	Hsu, 2016, Ruggiero & Mong, 2015	2
7	PL on formative assessment	Andersson & Palm, 2017; Box et al., 2015; Hollingworth, 2012; Koloi-Keaikitse, 2016	2
8	PL on tech	Blackwell et al., 2014; Ertmer, 1999; Hew & Brush, 2006; Karatas et al., 2017; Tas, 2017	2
9	Collaboration on formative assessment	Birenbaum et al., 2011, De Lisle, 2016; Hollingworth, 2012	2
10	Collaboration on tech	Blackwell et al., 2014; Ertmer et al., 2012; Heath, 2017; Hew & Brush, 2006; Hsu, 2016; Kopcha, 2012	2
11	EOCT class	Box et al., 2015; Ertmer et al., 2012	2
13, 16, 18, 21, 22, 26, 29, 30	Teacher comfort with instructional technology	Ertmer et al. 2012; Hew & Brush, 2006; Kopcha, 2012; Mac Callum & Jeffrey, 2014; Sadaf et al., 2016; Reinhart & Banister, 2009	3
17, 24, 25, 33, 34	Teacher-perceived Benefit of using instructional	Box et al., 2015; Hew & Brush, 2006; Heath, 2017; Hsu, 2016; Keane, 2012; Kopcha, 2012;	4

	technology	Mac Callum & Jeffrey, 2014; Tas, 2017; Sadaf et al., 2016; Reinhart & Banister, 2009	
12, 15, 20, 31, 32	Technology vision and support	Hsu, 2016; Kopcha, 2012; Reinhart & Banister, 2009	5
14, 19, 23, 27, 28, 35	Teacher-perceived autonomy	Birenbaum et al., 2011, Box et al., 2015; Cotton, 2017; De Lisle, 2016; Havnes, Smith, Dysthe, & Ludvigsen, 2012; Hollingworth, 2012; Lee et al., 2012; Missett et al., 2014; Irving, 2015; Vangrieken et al., 2017	6
36, 37	CBFA applications	Fuller & Dawson, 2017; Iwamoto et al., 2017; Shute & Rahimi, 2017; Vincent, 2016; Wash, 2014	1
38	Differing CBFA usage rates for class levels	Blackwell et al., 2014; Koedinger et al., 2010; Missett et al., 2014; Sheard & Chambers, 2014	2

APPENDIX E

RECRUITMENT EMAIL

2/7/2019 Gmail - Re: Permission to use instrument

Patrick Sullivan <patricksullivan306@gmail.com>
Re: Permission to use instrument

Katrien Vangrieken <katrien.vangrieken@kuleuven.be> Thu, Feb 7, 2019 at 3:05 AM
To: Patrick Sullivan <ps02449@georgiasouthern.edu>
Dear Patrick,
You can definitely use the questionnaire we developed if you refer to our paper published in TATE. It would be really valuable if the questionnaire is used in a different context. Of course I would recommend using the complete validated instrument rather than selecting only parts of it.
Good luck with your PhD!
Best,
Katrien
Van: Patrick Sullivan <ps02449@georgiasouthern.edu>
Verzonden: woensdag 30 januari 2019 4:21
Aan: Katrien Vangrieken
Onderwerp: Permission to use instrument

Dr. Vangrieken,
My name is Patrick Sullivan and I am a doctoral student at Georgia Southern University. I would like your permission to use parts of your questionnaire on Teacher Autonomy and Collaborative Attitude (2017) as part of my work on my dissertation. I am developing an instrument to conduct a correlational analysis of the frequency of computer-based formative assessment use in a 1-to-1 setting in grades 6-12 to a variety of demographic factors, and constructs, including Teacher Autonomy and Collaboration. Your validated instrument would be of great use to me for my study.
May I have your permission to use parts of your instrument in my doctoral study?
Please let me know if you need any additional information so you can consider this request.

Thank you,
Patrick Sullivan Ed.S
Georgia Southern University

APPENDIX F

REQUEST FOR PERMISSION TO USE INSTRUMENT

1/30/2019
Mail - Re: Request for permission to use Instrument

Sullivan, Patrick <ps02449@georgiasouthern.edu>
Re: Request for permission to use Instrument

Dr Rachel A Vannatta <rvanna@bgsu.edu> Tue, Jan 29, 2019 at 11:11 PM
To: "Sullivan, Patrick" <ps02449@georgiasouthern.edu>
You certainly have my permission. Best of luck to you! Rachel
Rachel A. Vannatta, Ph.D.
Professor; Assessment, Statistics & Research
School of Educational Foundations, Leadership & Policy
Bowling Green State University
Sent from my iPad

On Jan 29, 2019, at 8:54 PM, Sullivan, Patrick <ps02449@georgiasouthern.edu> wrote:
Dr. Vannatta-Reinhart,
My name is Patrick Sullivan and I am a doctoral student at Georgia Southern University. I would like your permission to use parts of your Teacher Technology Integration Survey (2009) as part of my work on my dissertation. I am doing a correlational analysis of the frequency of computer-based formative assessment use in a 1-to-1 setting in grades 6-12 to a variety of demographic factors, including the constructs, Comfort with Instructional Technology, Perceived Benefit of Using Technology in the Classroom, and Technology Support. Your validated instrument would be of great use to me for my study.
May I have your permission to use parts of your instrument in my doctoral study?
Please let me know if you need any additional information so you can consider this request.
Thank you,
Patrick Sullivan Ed.S
Georgia Southern University

APPENDIX G

RECRUITMENT EMAIL FOR STUDY PARTICIPANTS

Teachers of XXXXXX County,

My name is Patrick Sullivan and I am the principal of XXXXX Middle School. I am in the process of completing my Doctoral studies at Georgia Southern University. With the approval of Dr. Marc Guy, I am emailing you today to ask for your participation in my research study on Computer-Based Formative Assessment Usage in our district at the high school and middle school levels. This study is specific to academic teachers of English, mathematics, social studies, and science. The results of this study will inform district improvement efforts in the use of computer-based formative assessments and will provide valuable insight into how often teachers are using them with their students and the factors that influence teachers' frequency of use of these tools.

The data for this study will be collected through an online survey that contains 38 questions and should take you between 10 and 15 minutes to complete. I very much appreciate your time to complete the survey. As a thank you for participating, you will have the opportunity to be selected to win one of four $50 Amazon gift cards. The survey responses are needed as soon as possible, and no later than two weeks from today.

The link for the survey is below.

https://georgiasouthern.co1.qualtrics.com/jfe/form/SV_cITRJR93obXrLW5

Thank you,

Patrick Sullivan

APPENDIX H

FOLLOW-UP EMAIL TO TARGET POPULATION

Good morning,

This is a quick reminder about the survey I sent out last week and $50 Amazon gift cards. If you haven't already done so, it is not too late to complete the survey and enter the drawing. I will select the four winners on this coming Saturday and email the list of winners on Monday. Gift cards will be sent in the courier to your school next week...good luck! The survey should take about 10 minutes to complete. Thank you again to everyone that has already completed it!

https://georgiasouthern.co1.qualtrics.com/jfe/form/SV_cITRJR93obXrLW5

Patrick Sullivan