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Computer-Based Formative Assessment Practices of Core Academics Within a One-To-One Computing Environment[1]

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This correlational study examined the different types of computer-based formative assessments (CBFA) being utilized, frequency of CBFA use, and differences in CBFA usage rates across specified constructs in middle and high schools located in Georgia. 261 middle school and high school academic teachers were provided a Qualtrics survey and descriptive statistics, an ANOVA, and correlations were utilized to analyse the data. Findings noted a positive correlation between CBFA usage rates and teacher comfort with technology and perceived benefit of using technology, and a negative relationship between teacher autonomy to select teaching methods and CBFA usage rates. Additionally, teacher beliefs about the needs of their students are impacting their decisions to use CBFA. Through building awareness of differences in CBFA usage, researchers recommend for school leaders to encourage professional learning that is purposeful, collaborative, and sustainable, which can address the different perceptions educators have about the implementation of instructional technology. Additionally, it is encouraged for teachers to have a voice in the selection of CBFA applications used with their students and incorporating administrative directive to use CBFA applications.

Keywords: computer-based formative assessment, formative assessment, instructional technology, professional development, student achievement

[1] This study was produced from the data of the PhD thesis.

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INTRODUCTION

Currently, with a networked device readily available to nearly every student in Georgia and a wide range of free applications offered online for teachers to choose from, access to technology is often no longer a barrier to implementation in many schools (GADOE, 2020; Greenstein, 2010). Prior research has noted use of computer technology within the classroom as an effective approach to increasing academic performance and opportunities; however, 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 (Afshari et al., 2009; Box et al., 2015). Teachers face barriers such as weighing their own beliefs related to technology, fluctuating technology self-efficacy, desiring professional learning around technology, and needing ongoing technology support (Ertmer et al., 2012; Hsu, 2016). 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.

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 school district in Georgia to better understand the relationships between teacher usage rates of CBFA in their classrooms and their beliefs and attitudes toward technology. The following overarching and equally weighted research questions guided this study:

1. To what degree does teacher comfort with technology correlate to their frequency of use of CBFA in a one-to-one computing setting?

2. 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?

3. To what degree does teacher perceived technology support and vision correlate to their frequency of use of CBFA across class types and technological constructs in a one-to-one computing setting?

4. 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?

Review of the Literature

Overview

The literature on formative assessment will be reviewed in addition to the technology in education, first-order barriers to technology, second-order barriers to technology, effects of computer-based feedback, and computer-based formative assessments. Recognizing the impact of formative assessment on student achievement, a number of legislative mandates now require teachers to regularly use formative assessments in their classroom practice, and for administrators to systematically evaluate teachers on technology usage.

Formative Assessment

As formative assessments are commonly noted across literature within a broad scope to encompass a wide variety of evaluative methods, various operational definitions of this construct have been identified. 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). Greenstein (2010) expanded on this idea noting "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).

This study is guided by 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). Uniquely, feedback is the key element within formative-based assessments comparative to summative evaluations (Sadler, 1989). More specifically, in order to effectively utilize a formative assessment model, the learner must understand the goal or standard, use standardized comparisons for performance levels, and develop achievable action to reduce discrepancy between output and goal performance (Sadler, 1989).

Technology in Education

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 (Ertmer, 1999). Additionally, technological issues such as non-functioning hardware or unreliable internet access meant that access to the technology was not assured. 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 computing (Varier et al, 2017; Zheng et al., 2016). Smartphones and tablets usage in the classroom have been shown to have a positive effect on student learning, notably within critical thinking skills, problem-solving skills, and autonomy in learning (Aminatun et al., 2022).

The rapid expansion of access to high-speed wireless internet in schools has been simultaneous with the advancement of computer hardware, and the availability of a large number of web-based applications called Web 2.0 tools (Wells & Lewis, 2006). 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 districts 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 effective at accomplishing support of teacher use of technology (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 assumptions about technology in education as well as 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 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, a lack in confidence and knowledge within the teacher 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).

Effects of Feedback on Computer-Based Formative Assessments

This feedback can take different forms depending on the application being used and may result in the teacher or another student providing the feedback (Alcoholoda et al., 2016; Maier et al., 2016; Sheard & Chambers, 2014). Additionally, the applications will often provide either simple verification of the correctness of an answer or provide more elaborative feedback. Furthermore, 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. 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). 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 in providing instructional technology to their students.

Computer-Based Formative Assessments

Formative assessments are utilized to assess the performance of the individual student, and provide feedback based on the data collected (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.

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 discussions. It is the current CBFA practices of teachers within one school system that this study will explore further.

METHOD

A correlational research design was utilized to examine different types of CBFA being implemented in six middle schools and three high schools within one mid-sized suburban school district in Georgia. An online Qualtrics questionnaire was developed to obtain self-reported answers from the study participants. The targeted participants included collectively 414 middle school and high school academic teachers. Teachers were contacted via school system email distribution lists and the initial email contained the purpose of the study, the rationale for their invitation to join the study, and a link to the questionnaire. Participants were provided a two-week timeframe for submission of their responses and after one week, a reminder email was sent to all targeted participants. A total of 280 responses were collected and, of these, 261/414 were complete yielding a 63% response rate.

The focus of this study was to examine the number of days that the teacher had chosen to use a CBFA with students during class time as well as address the different levels of classes that the teacher had been teaching (advanced or gifted, collaborative, or on-level classes). This resulted in three CBFA usage quantities that were examined separately and as an overall average of CBFA usage for that teacher. Additionally, the instrument included eight demographic questions, class specific information, teacher collaboration and professional learning experiences, 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). Furthermore, 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. Descriptive statistics, an ANOVA, and correlations were utilized to examine which CBFA applications teachers were using to formatively assess their students over the prior 30 days based on comfort level and perceived benefit of the specific instructional technology. Furthermore, correlation and descriptive statistics for frequency of CBFA usage across class types, teacher average CBFA usage, and the specified constructs were calculated.

FINDINGS

The research findings in this chapter are presented in several sections related to each of the four research questions. These findings denote CBFA usage 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 correlate to the frequency of CBFA usage across class levels and teacher average CBFA use for the teachers in this study. As an overview, correlation and descriptive statistics for frequency of CBFA usage across class types, teacher average CBFA usage, and technological constructs are presented in Table 1.

Table 1
Correlation and descriptive statistics for frequency of CBFA usage across class types, teacher average CBFA usage, and technological 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.
$n = 261$
$^{**}p < .01$.

Teacher Comfort with Technology

The first 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 two, three, and four, 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 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.

Perceived Benefit of Technology

The second 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 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 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 ($M = 2.25$) was 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 third 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 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 indicated no significant relationships with any of the five items for any of the class levels or the teacher average CBFA usage. This result implies 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. See Table 2.

Table 2
Correlation and descriptive statistics for technology support and vision construct 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.
**$p < .01$.

Teacher Autonomy

The fourth 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 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. See Table 3.

Table 3
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.Collabor-ative	.91**	.94**	-							
4. Teacher verage	.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.
*$p < .05$. **$p < .01$.

DISCUSSION

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. 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.

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 between the frequencies of use of CBFA was found for all levels of classes. This last finding seems contrary with 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", indicating that administrative demands often drove teachers to incorporate technology in instances when they may not have chosen to do so (p. 358). 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.

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. Comparatively, several studies supported the idea of internal beliefs playing the most significant role in the use of these practices in the classroom (Box et al., 2015; Ertmer, 1999; Hew & Brush, 2006; Minshew & Andersson, 2015). The current study confirmed these findings 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 aid in achieving both of these goals. The findings of this study bolster the understanding of teacher beliefs in shaping the frequency of CBFA usage and can further support school leaders and teachers in developing support systems to magnify computer-based instructional practices.

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 with students.

LIMITATION

This study was limited to a single 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. 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.

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 schoolyear 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.

RECOMMENDATION

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 school district in Georgia. The study could be expanded by replicating this procedure with additional school districts across the nation that are using personal computing devices in a one-to-one ratio. Taking a more comprehensive view of CBFA usage across locations would allow an increase in the ability to generalize findings.

2. 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 abundantly explore the unique barriers to CBFA usage in this class setting.

3. 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 supports 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 also highlighted that teacher beliefs about the needs of their students are impacting their decisions to use CBFA in their classrooms. Differences in teacher beliefs about student learning are related to the frequency of computer-based formative assessments usage by teachers. As school leaders plan for professional development focused on instructional technology, awareness of these differences in CBFA usage can be instrumental in crafting professional learning that is purposeful, collaborative, and sustainable, which can address the different perceptions educators have about the implementation of instructional technology.

In one-to-one computing environments, access to technology is no longer a barrier to using CBFA tools with students as it is readily available. 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. Building 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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