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Exploring the Dimensions of 21st Century Skills in High School-Based One-to-One Initiatives: Creating and Validating a Scale Using Mixed Methods Research

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EXPLORING THE DIMENSIONS OF 21ST CENTURY SKILLS IN HIGH SCHOOL-BASED ONE-TO-ONE INITIATIVES: CREATING AND VALIDATING A SCALE USING MIXED METHODS RESEARCH

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Title: Exploring the Dimensions of 21st Century Skills in High School-Based One-To-One Initiatives: Creating and Validating a Scale Using Mixed Methods Research

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This mixed methods study explores students' and teachers' perceptions of 21st century skill development (i.e., collaboration, communication, creativity, critical thinking, content mastery, and digital literacy) in high schools with one-to-one initiatives. Analysis of data from seven student focus groups and seven one-on-one teacher interviews revealed that high school students and teachers held similar perceptions around 21st century skill development. Both groups acknowledged that students' communication, collaboration, and critical thinking skills were supported through one-to-one initiatives. Despite their involvement in one-to-one initiatives, students struggled to explain digital literacy, with their definitions more limited than 21st century-skills-based literature definitions. Content mastery, although not generally included in 21st century skills frameworks, emerged as a skill in one-to-one initiative schools with both teachers and students. Across schools, students and teachers indicated a digital divide between university-bound students and those aspiring to the work world after graduation. The 54-item instrument resulting from the qualitative data was assessed by 12 subject matter experts for validity and reliability. After eliminating items, 53 undergraduate education majors assessed the remaining 34 items. Analysis of variance (ANOVA) and a Games-Howell post hoc test determined significant differences between perceptions of items adhering to 21st century skill domains. Finally, exploratory factor analysis was used to guide item rewording for post-study pilot testing. The final 31-item instrument is a reliable and valid measure of 21st century skill development in high schools with one-to-one initiatives. While analyses suggest that one-to-one initiative high schools hold the potential to develop 21st century skills, each domain was supported inconsistently, with more items describing communication (n = 8) and fewer items describing collaboration items (n = 3). Items expressing creativity reflect an expanding definition, adding developing virtual models, creating new ways to do things online, and solving digital world problems to fine arts-associated definitions. Items associated with critical thinking reflect an enlarged understanding of the competencies necessary for operating in technology-rich classrooms. Content mastery reflects the finding that high school students use school devices to augment their classroom learning outside of class, supplementing instruction but not supplanting the teacher. Implications for professional development and future studies are offered.

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I was told years ago that writing a dissertation is like giving birth; however, being something of an expert on this topic, I would have to say that this statement is inaccurate. The process involves way more people, for one, than gestation. And it seems that the final product weighs more than a newborn.

As I sit at the wooden table that has become my home over the past year and shift on the terribly uncomfortable oak chair that now bears wear from excessive seat time, I consider the relative damage done to my body by this process—the near blindness, the loss of muscle tone, and an enormous caboose. The sheer physicality of writing has astonished me, and in that way the analogy of childbirth is accurate. However, at the end of this process I find I am holding not a newborn (whew) but a product that is the total sum of a long career in education. Years of classroom teaching and inspiring colleagues, endless encouragement from friends near and far, years of classwork and training, and my own children's schooling experiences all contributed to this dissertation. I do not have the space to thank the hundreds of thousands of people who helped me to the point where I could devote five years of my life to this process.

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Finally, I need to thank my husband, Tony. I had never intended to take a doctorate, and it was because of him that I undertook this degree in the first place. Without his addiction to Woot, Facebook, Imgur, e-mail platforms, and YouTube, he would have finished long ago with his own dissertation. I thank him, therefore, for spending countless hours staring at these platforms instead of working on his dissertation. That means, Tony, that I won this one and that that fortune teller was right all those years ago. You ARE riding my coat tails!

On on!

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CHAPTER ONE

INTRODUCTION

Since the 1990s, information has been recognized as one of society's most important economic resources, taking its place next to labor, financial capital, and natural resources in the world economy (Drucker, 1993). Information is a powerful asset in the modern economy, so it is important that we determine an effective approach to educating people for a lifetime of discerning useful information from information that is misleading. What is the best way to help people learn to analyze the cascade of information with which they are bombarded each day? How can teachers instruct students in order that they might deal with an information-rich environment? Most important, what is the best way to educate students for what is likely to be a lifetime of working in collaboration and communicating with others in creative exchanges of information?

Facilitating students' meta-awareness of learning and content acquisition is regarded as one of the keystones in developing 21st century skills by Battelle for Kids, which was formerly called the group Partnership for 21st Century Skills (P21) (Batelle for Kids, 2019), and the ostensibly resultant independent, problem solving, lifelong learner is appealing in a world plagued by uncertainty as to what skills future job markets might require (Beers, 2011). One of the suppositions upon which the argument for teaching 21st century skills is based is that a child who is educated to be a thoughtful and creative communicator and collaborator would be an asset in any industry, even one that has not yet been created (O'Toole & Lawler, 2006). While creating such an individual sounds tantalizing, implementing policies, curricula, and assessments that support such a goal has proven elusive (Voogt & Pareja Roblin, 2012).

Although he was certainly not the first politician to do so, Alan Greenspan spoke at the turn of the century on the importance of educating for an unclear future, simultaneously encouraging equity of educational access, innovation, and learning for the new century, which he described as a "dynamic period of American economic history" (para. 20). A year later, in 2001, Greenspan delivered an address to the Community Affairs Research Conference of the Federal Reserve System in which he tied together the roles of technology, business, and educational technology to an unknowable future:

> The twenty-first century will certainly bring us new technologies and, along with them, new challenges and new possibilities. We cannot know the precise directions in which technological change will take us…Building bridges between our educational institutions, the private business sector, and community organizations will be an essential aspect of our efforts to increase familiarity with new technological…tools that are fundamental to improving individual economic well-being. And the success of such efforts will have a critical bearing on how well prepared we are to meet the challenges of an increasingly knowledge-based global economy. (para. 17)

In 2001, as the school year was ending, Alan Greenspan was connecting the three threads that are woven throughout the current study—digital technologies, skills for the future, and student preparation for the one (the future) through the other (digital technologies).

The idea of education as a field with concerns increasingly extending beyond simple content delivery and school-based skills had been evolving since the formalization of public education. Notable landmarks throughout the 20th century—the launching of Sputnik in 1957, the resultant National Defense Education Act (1958), and the publication of *A Nation at Risk* (National Commission on Excellence in Education, 1983)—spurred educational visionaries to turn toward education for the future. At the close of the 20th century, there was increasing cognizance of the potential role of technology as a bridge builder between previously segregated segments of society, including the economic and business sectors and community organizations, as reflected in 2001 in Greenspan's comments.

With the growing ubiquity of 21st century rhetoric in general society and political realms, it was perhaps inevitable that educational institutions of the United States would also build 21st century rhetoric into mission statements, websites, handbooks, and parent literature. In addition, the inconsistent manner in which schools, teachers, students, administrators, school boards, community members, and policy makers have come to define the term "21st century skills" may also have been inevitable given the manner in which the concept has evolved and the lack of concrete terminology in the resultant definitions.

Reflecting this issue, in 2010 a cohort of education experts was asked to define and explain 21st century skills and their benefits to students, yielding a variety of views on the subject (Rich, 2010). Responses ranged greatly in focus. Some respondents equated 21st skills with classroom technology use while others explained 21st century learning as an equity-based exercise (Rich, 2010). Others avoided mentioning technology entirely and focused instead on the importance of soft skills such as creativity, communication, and collaboration. In short, among education experts, there was a lack of consistency in perceptions of what constitutes a 21st century skill set and expression of what is necessary to guide students into a 21st century model of education.

Without a clear map to guide this move into the dynamic 21st century, the field of education has been left to make the move through what often seems a logical route—digital technologies—and, more specifically, one-to-one initiatives. Since the mid-twentieth century, computers have become increasingly ubiquitous in the schools of the United States. In the 1950s, when computers first were meshed with the realm of classroom education, the world was embroiled in Cold War competition with a focus on quantitative data and a call for a return to the "basics" of education (i.e. more homework, more hours spent in the classroom, and a longer school year); interestingly, there was no talk of the "human" aspects of education or on rethinking or redesigning curricula, and the classroom computer-centered research that followed often mimicked this "back to basics" focus (Besser, 1993).

In 1951, with the completion of the Illinois Integrator and Automatic Computer (ILLIAC), the first educational computer, researchers and educators sat on a precipice, struggling to gaze through a thick cloud cover to an unknown future. More than any other unknown was the lack of clarity surrounding the role that a computer could play in a classroom. Would computers one day stand in place of students attending physical classes while pupils remained at home, thereby saving taxpayers millions of dollars each year in physical building costs? Or would computers eventually unseat teachers and provide the instruction? At the dawn of computing, there seemed no other way for the world to go than to extremes, with computers single-handedly destroying the educational status quo, unnerving scores of teachers while exhilarating legions of school children.

In the first quarter of the 21st century, an increasing number of public K-12 schools have embraced technology in the classroom without the apocalyptic effects feared fifty years ago (Molnar, 2015). However, the debate on the efficacy of such programs is ongoing. Researchers have highlighted the lack of evidence of consistent progress for students involved in technology-supported learning initiatives (Abell Foundation, 2008; Carr, 2012; Grimes & Warschauer, 2008; Lowther, Inan, Ross, & Strahl, 2012). Zheng, Warschauer, Lin, and Chang (2016) suggested that a lack of strong statistical evidence and systematic analysis coupled with weak research methodologies has muddied empirical findings on the efficacy of ubiquitous computing initiatives. Because one-to-one initiatives may develop 21st century skills in addition to advancing students' academic achievement, researchers have issued a call for further research on possible links between the two variables (Collier, 2008; Lowther et al., 2012; Mast Ryan, 2013; Zheng et al., 2016). The intersection of these two areas of research is where the current study is situated: what is the relationship between perceptions of 21st century skill development and involvement in one-to-one initiatives?

Problem Statement

One-to-one initiatives have been implemented worldwide. In the United States, settings range from tiny, isolated school-based programs to district-wide programs as in Henrico, Virginia, to statewide programs as in Maine (Hanover Research Council, 2010). However, these initiatives come with a hefty price tag. In 2013, a school district in Alabama was spending nine million dollars annually on its one-to-one initiative programs in its middle and high schools (Rhor, 2013). The costs of such an initiative extend far beyond the simple price of purchasing one device per student because infrastructure, training, repairs, updates, and replacement hardware and software all must be factored into the cost equation (Minnesota Department of Education, 2016). Despite the investment required to implement a one-to-one initiative, few schools have a metric by which they assess the success of such initiatives beyond standardized state test scores, even though research has suggested that such scores cannot sufficiently measure the skills that ubiquitous computing initiatives develop (Zheng et al., 2016).

As decision makers and researchers have increasingly scrutinized one-to-one initiatives, they have noted improvements in student engagement and achievement and decreases in student absenteeism (Abell Foundation, 2008; Allington, 2014; Baines, 2015; James-Burdumy et al., 2010; Fisher & Ivey, 2006; Slavin, Lake, Davis, & Madden, 2009). This increased engagement suggests that students may be acquiring other skills that have heretofore gone unrecognized. Specifically, students may be developing 21st century skills (Collier, 2008; Lowther et al., 2012; Mast Ryan, 2013; Zheng et al., 2016), especially in consideration of the proposition that effective use of technology in the classroom holds the potential to shift the teaching-learning paradigm away from traditional, didactic teaching approaches and toward a more learner-centered, learner-driven, inquiry-based model (Carlgren, 2013; Kivunja, 2014). However, in the rush to embrace 21st century skills and the technology that constitutes just one piece of 21st century skills frameworks, little empirical research has been done to advance a sound understanding of the relationship between the medium of information delivery, specifically in one-to-one initiatives, and perceptions of 21st century skill development.

Research Questions

This study's primary purpose was to create a validated, reliable instrument to measure high school students' 21st century skill development (i.e., collaboration, communication, content mastery, creativity/innovation, critical thinking, and digital literacy). An activity-theory-based qualitative exploration of three high schools with one-to-one initiatives guided this exploration. The research questions guiding this study include the following:

Research Question One: What outcomes are identified within an activity system in which one-to-one devices are the mediating artifact?

Research Question Two: What 21st century skill development is identified by students and teachers in an activity system in which one-to-one devices are the mediating artifact?

Research Questions Three: What items in a 21st century skill-measuring instrument represent the results of the qualitative phase of research?

Significance of the Study

This study provides important information in several contexts. First, this study forwards empirical information on students' 21st century skills development in relation to one-to-one initiatives. The information obtained provides evidence that could allow school officials to make improvements to curricular design to respond not only to the content of learning in the classroom but also the context. In relation to one-to-one initiatives, the study contributes to a limited body of research on the possibility of ubiquitous computing initiatives helping students develop 21st century skills. For the schools and districts where this study was conducted, the results allow for curricular modifications to support skill development, possibly serving as a guide to strengthen skill-based outcomes for all students, better preparing them for future success.

The resultant validated tool may be used in districts where teachers and administrators are trying to broaden students' educational experience. The nuanced findings of the qualitative study contributed to an instrument that imparts a picture of skill development in the study schools. The proposed instrument will allow measurement of non-academic skill acquisition after piloting.

Finally, regarding the current focus on how to best prepare students for postsecondary success in both college and career, these results could advance the dialogue regarding the potential role that ubiquitous access can play in school reform. Findings in this realm may help stakeholders to identify replicable practices in classrooms that, if applied in other disciplines, could increase 21st century skill development for more students. Additionally, these results could be utilized to guide technology-based curriculum and strategy development to strengthen the connection between instruction and 21st century skill development, and more closely meeting college and career readiness objectives in future high school programs.

Definitions and Key Terminology

In the literature, it is well agreed upon that 21st century skills extend beyond the hardware associated with technology to cover four general areas: collaboration, communication, creativity/innovation, and information and communications technology (ICT) literacy, which in this study is ascribed “digital literacy” (Antonaci, Ott, & Pozzi, 2013). As stated earlier, however, definitions of these areas lack clarity between studies. In this study, participants noted six 21st century skill domains as detailed below. In addition, terms associated with classroom and school-wide technology use are discussed.

21st Century Skills

Voogt and Pareja Roblin (2012) noted four specific areas of focus consistent across 21st century literature worldwide—communication, collaboration, ICT literacy, and civic and global citizenship. In addition to those four areas, participants in the current study identified digital literacy, content mastery, and critical thinking as 21st century skills. Many definitions of these specific 21st century skills are explicated in the literature, but the definitions around which the current study was primarily built are those of Battelle for Kids. Battelle for Kids, formerly called the Partnership for 21st Century Skills P21, is a non-profit, catalyst organization uniting businesses, educational leaders, and non-profit organizations and has led the way into the 21st century education movement (2019). As with the study by Voogt and Pareja Roblin (2012), Battelle for Kids (2019a) defined 21st century education as constituted, among other skills, of collaboration, communication, creativity, and abilities associated with ICT.

Collaboration. In the newest P21 Framework (Battelle for Kids, 2019b), collaboration is grouped with communication and is also intricately woven into the other skills expressed. Collaboration is the ability to work effectively and respectfully within diverse settings while sharing responsibility, making compromises, exercising flexibility, and displaying willingness to work toward and achieve common goals (Battelle for Kids, 2019b). Maintaining an open mind also plays an important part in this conceptualization of collaboration.

Communication. Communication is the ability to articulate thoughts and ideas effectively using oral, written and nonverbal skills, and to listen in order to decipher meaning and intentions in a variety of contexts and diverse environments, including those that are multi-lingual (Battelle for Kids, 2019b).

Creativity/Innovation. While creativity and innovation are not synonymous with one another, they are closely related; c*reativity* is the ideation of a thought, innovation is the realization of that idea. Creativity is marked by the ability to generate a steady flow of ideas, remain flexible with one's thinking, recognize the importance of failure, and elaborate on an idea while imparting uniqueness to the final, innovated product; innovation involves acting on ideas (Battelle for Kids, 2019b).

Digital literacy/Information and communication technology (ICT) literacy. Digital literacy is not limited to simple knowledge of the use of hardware but is constituted of learning "to inquire, build and test ideas, categorize, summarize, make decisions based on information and experience, and to act on these decisions while continuously collecting new information" (Joyce, 2011, p. 53). In addition, digital literacy in the one-to-one context encompasses self-monitoring skills in which students direct their technology use rather than relying on teachers or parents to do so (Zimmerman, 1989). Finally, literacy in this area means managing the information that is obtained through various media while demonstrating an understanding of how and why media messages are constructed (Battelle for Kids, 2019b). As this study evolved, the term “ICT literacy” proved confusing for participants. Feedback suggested that the term “digital literacy” should be used instead. Thus, from this point onward, “digital literacy” is used to in place of ICT literacy in discussions of the current study. However, if ICT literacy is used in a particular published work, then that term is the one used when discussing that piece of the literature.

Bring-Your-Own-Device Initiative

It is important to note that a one-to-one initiative within the context of the current research is not the same as a bring your own device (BYOD) initiative. In a BYOD, students, teachers, and administrators bring their own mobile devices, including laptops, iPads, Chromebooks, or other devices for their exclusive use within the classroom but under a common server as opposed to one-to-one initiatives, where students are issued common devices to use under a common server (Emery, 2012).

Cart Model

An additional model of technology integration, a cart model is a technology initiative in which the school or district has purchased for in-class use a collection of devices which teachers can check out on a daily basis for use when necessary within the teacher’s classroom. However, students cannot use the devices after school hours outside of the school building.

Non-Initiative Schools

Non-initiative schools are defined as those that have not currently adopted a one-to-one initiative.

One-to-One Initiative

In the current study, a one-to-one initiative (also referred to as “ubiquitous computing” in some studies) is a district-funded initiative in which all students, teachers, and administrators are supplied with a common type of device (e.g., iPad, Chromebook, or branded laptop) to access connectivity 24/7 both in and outside of the classroom. According to the Abell Foundation (2008), the intention of a one-to-one initiative is four-fold: To improve academic achievement by changing instructional methods to be more student-centered; to require higher order thinking in the student body; to teach 21st century skills, and to provide more scaffolding to students in need of learning opportunities. By utilizing a common, school-supplied device throughout a school, an additional hallmark of the 21st century classroom is encouraged—equity of access to information and learning tools (Joyce, 2011).

Theoretical Framework

Derived from the work of Vygotsky (1978) and expanded upon by Engeström to explain the operation of systems, an activity system provides a model by which an organization can be conceptualized as a dynamic unit. The unit, through interactions (called tensions in the activity system model), elicits outcomes, and the theory aims to explain how people within the systems arrive at outcomes (Cole & Engeström, 1993). As activity theory attempts to capture the complexity of a system, it is necessary to be familiar with the seven aspects of the activity system model: tools, subject, object, rules, community, division of labor, and tensions.

Tools

Tools, which are also referred to as “artifacts” in the literature, are the physical or psychological items that mediate activity between the subject and object (Cole & Engeström, 1993). In the current study, the tool is the laptops.

Subject

The subject constitutes individuals involved in the activity of the system (Cole & Engeström, 1993). In the case of the current study, the subject is the teachers/students.

Object

The object is the motivating influence that drives participants' participation in the activity (Cole & Engeström, 1993). In the current study, the object is the integration of laptop computers into the school's daily operations, teachers' practice, students' learning and a school's curriculum.

Rules

Also called norms, rules are what govern the function of the system (Cole & Engeström, 1993). In the current study, the rules are formal and informal norms that govern the interactions within the activity system.

Community

The community is the social or cultural group to which subjects belong with rules that regulate behavior (Cole & Engeström, 1993). In the present study, the community is the stakeholders that surround the school and include the school board, the parents, the administration, and possibly the parents and students.

Division of Labor

The division of labor defines how tasks and responsibilities are shared among the elements of system as they participate in the activity (Cole & Engeström, 1993).

Tensions

Tensions are interactions between different elements within an activity system. However, these interactions should not necessarily be considered negative. The tensions are simply interactions that energize transformation within a system (Cole & Engeström, 1993; Yamazumi, 2008).

Purpose of the Study

This study's primary aim was to create a validated reliable instrument through which 21st century skills might be measured in high school students. This end was accomplished by exploring and describing stakeholders' perceptions of the development of 21st century skills (collaboration, communication, creativity/innovation, critical thinking, and digital literacy) in one-to-one computing initiative schools. The qualitative portion of the study explored tensions existing within high school activity systems and their perceived contributions to 21st century skill development in three American high schools with one-to-one initiatives. This research contributes to the body of literature on 21st century skills and one-to-one initiatives by providing a validated instrument based on empirical evidence regarding the relationship between the two areas.

Research Design Overview

The study followed an exploratory sequential mixed methods approach in which the qualitative data collected in phase one of the study drove the development of a validated instrument in phase two (Creswell, 2014; Morgan, 1998). In an exploratory sequential mixed methods approach, "One database builds on the other and the data collection can be spaced out over time" (Creswell, 2014, p. 225). Thus, the researcher carried out the qualitative phase of the study first followed by data analysis and the development of a validated, reliable instrument.

The participants in phase one of the study were affiliated with three high schools with ubiquitous computing initiatives and statements related to 21st century skill development in their district- and/or school-based literature. Participating schools embraced varying curricula and standards, were located in three distinct geographical areas of the Eastern United States and served populations with varying socioeconomic characteristics. The researcher collected data at each school site through classroom observations, teacher interviews, and student focus groups, lending greater clarity to the relationship between one-to-one initiatives and 21st century skill development. Phase one of the study concluded with thematic analysis of data.

Phase two of the study was devoted to developing a survey that aims to confirm the findings of phase one, with rounds of checks to determine validity, reliability, and adequacy of the proposed instrument. Subject matter experts (SMEs) evaluated the proposed items for clarity and favorability toward one-to-one initiatives. A modified kappa (MK) coefficient, item content validity index (I-CVI), and scale content validity index average (S-CVI/Ave) were calculated to reflect the items' reliability and validity (Lawshe, 1975). A 53-member panel assessed the extent to which the proposed survey items were consistent with the dimensions of 21st century skills. The researcher determined content adequacy through an analysis of variance (ANOVA) between the 34 items in six domains (Hinkin, Tracey, & Enz, 1997) and used an item-by-item Q-correlation matrix followed by exploratory factor analysis (EFA) to help determine the need for clarification, rewording, and potential adherence to the 21st century skill domains (Schriesman, Powers, Scandura, Gardiner, & Lankau, 1993).

Assumptions

Assumptions associated with this study have been divided into limitations and delimitations and are listed below.

Limitations

A number of limitations are associated with the current study.

1. The data collected constitute self-expressed perceptions of skill development using an arbitrary Likert-type scale.
2. The study did not attempt to determine exposure students may have had to the development of 21^{st} century skills prior to high school or their involvement in a one-to-one initiative.
3. Many variables outside of the control of the researcher or the current study may have impacted students' 21^{st} century skill development in relation to technology, including early childhood experiences, the quality of school-based programs, students' involvement with extracurricular activities, and parental involvement with students outside of school.
4. At the outset of the study, the researcher was a novice with limited experience in conducting empirical investigations independently.

Delimitations

Delimitations contributed to the strength of the current study.

1. The mixed method research design contributed to greater reliability of the findings and gave a broader view than an exclusively quantitative or qualitative study.
2. A mixed methods design allowed an examination of both predetermined and emerging themes, strengthening the coverage of the analysis (Creswell, 2014).
3. By examining three schools with very different characteristics, the findings produced a fuller picture of how one-to-one initiative schools can differ.
4. The instrument was developed through a multi-phase process, contributing to the rigor of the process of instrument development as well as the final instrument.

Summary and Overview of the Study

The current study determined the influence of one-to-one initiatives on high school students' perceived 21st century skill development. The literature, which has focused on the link between technology and student development, has primarily focused on computers' effects on students' academic achievement while largely disregarding the possibility of a link between digital technology and 21st century skill development (Zheng et al., 2016). In an attempt to answer the research questions proposed earlier, the dissertation followed a six-chapter design. Chapter one gives a general overview of the study. Chapter two covers the literature on 21st century skills, one-to-one initiatives, the intersection between the two areas, and the theory upon which the study will be built. To establish the rationale for arriving at this study at this point in time, chapter two also briefly covers a history of the development of technology in the classroom and the development of 21st century skill rhetoric. Chapter three discusses the theoretical basis for the use of a mixed-methods methodology and outlines the steps of the study's methodology. Chapter four present the study's qualitative findings, while chapter five focuses on the quantitative findings. Chapter six contains a discussion of the findings, the implications for students, teachers, and schools, and a conclusion. The findings of the study contribute to the literature through a mixed methods study of students' and teachers' perceptions of one-to-one initiatives contributions to developing skills in communication, collaboration, digital literacy, critical thinking, content mastery, and creativity/innovation.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Chapter two is woven from three literature threads—writings and studies having to do with one-to-one initiatives, activity theory, and 21st century skills. The first section of this chapter will focus on one-to-one initiatives. Specifically, the chapter will contain a brief discussion of the history of computers in America's classrooms, with special focus on one-to-one initiatives and their emergence in American public schools. The second section of the literature review will introduce activity theory. The third section will follow with a discussion of the 21st century skills movement's origins. Specifically, the chapter will detail the development of the notion of special skills for a new century through a discussion of the various frameworks that have been proposed to explain 21st century skills and the theories upon which the 21st century skills movement is based: post-industrialism, post-capitalism, post-modernism, and egalitarianism. The fourth section will discuss skills that have been identified as essential for students' future success. The fifth section of the literature review will focus on empirical works associated with activity theory, one-to-one initiatives, and 21st century skill development. A conclusion will follow, leading into the methodology chapter.

Computers in the Classroom

One-to-one initiatives in their current incarnation have evolved over more than half a century, beginning at the University of Illinois in the 1950s with a massive computer housed in a laboratory with two other digital behemoths. The evolution continues through to the present day, in which students carry compact digital devices with more memory power than those three early computers combined. In addition to the hardware and software developments that have occurred through the decades, the years have been marked by contention over how technology can best be employed to develop students' skills. Much more can be written about the development of classroom computers in the United States than space allows in a literature review. Thus, this section of the literature review will only briefly address in snapshot fashion the development of a technology culture in American classrooms. This section will then briefly highlight the historical trend of perceptions of the purpose of classroom computers in student and societal development.

The Development of the Classroom Computer

The computer in the classroom traces its origins to 1952 and the Digital Computer Laboratory, which is now the Department of Computer Science, at the University of Illinois-Urbana (Goldstone, 1972). At the time, computers were largely the province of the military and research laboratories, but the University of Illinois was one of the first educational institutions to have an automatic electronic digital computer, which was named the Illinois Integrator and Automatic Computer (ILLIAC) and used largely for rapidly processing arithmetic information (University of Illinois Archives, 1954). ILLIAC facilitated the next step in the journey toward the development of computer hardware suitable for the classroom.

The 1960s. In the 1960s, the Programmed Logic for Automatic Teaching Operations (PLATO) system was designed at the University of Illinois-Urbana and connected to the ILLIAC as well as a used black and white television, a storage memory tube, and a keyset so that the user could communicate with the system (Computer-based Educational Research University of Illinois Urbana-Champaign, 1977). In spite of this advance in computing technology, the feasibility of the mass distribution of computers was still poor until the 1970s when advances in the commercial production of plasma panels made the technology more widely available (Computer-based Educational Research University of Illinois Urbana-Champaign, 1977). Consequently, software development rapidly advanced and, in 1972, PLATO IV was launched with ten terminals running a system devoted to adaptive educational drills, and eventually hundreds of systems were in use in classrooms throughout the United States (Computer-based Educational Research University of Illinois Urbana-Champaign, 1977).

The 1970s. The 1970s brought about a seminal debate about the role of computers in the classroom. The PLATO learning system discussed in the previous section was not universally well received. The mathematician, computer scientist, and educator Seymour Papert was a vocal critic. Papert was one of the first educators to look beyond the drill-and-practice use of classroom computers and suggest a different pedagogical approach to computer education. Papert developed Logo as an educational programming language in conjunction with Daniel G. Bobrow, Wally Feurzeig, and Cynthia Solomon in 1967 pursuant to his Piagetian belief that learning to communicate with computers can be a natural process (Logo Foundation, 2015), like learning a language by living in a country rather than studying a language in a classroom (Papert, 1980).

Papert (1980) opined that computer use in the schools in the 1970s was heading in a disturbing direction in which "the computer is used to put children through their paces, to provide exercises of an appropriate level of difficulty, to provide feedback, and to dispense information" (p. 19) rather than conveying to children "a sense of mastery over a piece of the most modern and powerful technology and [establishing] an intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building" (p. 5). In essence, Papert (1980) advocated employing a constructivist pedagogy to facilitate students' control of technology over a behaviorist pedagogy through which students would only learn to be controlled by technology.

Contemporary to Papert's work with Logo, Patrick Suppes pioneered integrated learning systems (ILSs), software programs commonly focused on remediation and comprehensive instruction in content areas that included reading, foreign language instruction, and math skills (Wilson, 1990). ILSs were initially used largely with students who were considered at risk or troubled as the systems had been found to most engage students who had displayed behavioral or academic trouble in the classroom (Computer-based Educational Research University of Illinois Urbana-Champaign, 1977). Although more than a dozen ILS companies emerged in the 1980s, Suppes' Computer Curriculum Corporation (CCC) provided a high-end ILS tutorial instruction system that also collected comprehensive data on student progress on its networked systems (Kulik, 2002). Suppes' (1979) view of the classroom computer was not revolutionary; in his view, the computer was just one more change in information delivery in a long line of changes that stretch throughout history, beginning with the shift in ancient Greece away from oration and toward the written word.

Papert (1997) criticized the ILS's role in educational reform for failing to engage students as active entities in constructing their learning. Indeed, the two scholars held conflicting views of the fundamental nature of computers, since Suppes (1979) viewed them as not constituting "in any serious sense a new or formidable threat to human individuality and freedom" (p. 175). Suppes also could not envision the possibility of computers supplanting teachers in the educational process because he viewed teachers as indispensable agents in interpreting data and controlling the students' interaction with the computers (Computer-based Educational Research University of Illinois Urbana-Champaign, 1977). In contrast, Papert (1980) viewed interaction with computers as a natural process of building communication skills and one that is best done without explicit instruction, thereby supplanting the traditional classroom teacher.

Finally, the two scholars differed in their perceptions of the computers' proper places in schools. Suppes' ILSs were often lab-based within schools, a fact which Papert criticized in *Why School Reform is Impossible* (1997). Papert wrote, "Before the computer could change school, school changed the computer" (p. 419) as a statement of the manner in which technology was being used in education. By isolating terminals away from the real business of the classroom, computers were both accepted into schools but rejected due to their potential to subvert the traditional goings on of the traditional classroom and facilitate what Papert considered genuine learning (1997). A more recent response to the debate between Papert and Suppes is that, no matter the approach chosen to the classroom implementation of computers, if the computer-assisted instruction (CAI) programs are poorly designed and lecturers are boring, the outcome likely will be low test scores and negative reactions from students (Ross, Morrison, & Lowther, 2010). For the current study, the implication is that in spite of the use of technology, students will fail to make gains in academic achievement or 21st century skills development if one-to-one programs are poorly designed and implemented and lectures are disorganized or unappealing (Ross et al., 2010).

The 1980s. Instead of the 1980s being a time of widespread classroom technology innovation as might be suggested by the hardware advances arising out of Silicon Valley at the time, the implementation of classroom technology was limited. Perhaps due to the lack of sufficient research on the use of microcomputers in classrooms in the 1970s and early 1980s, it was noted that the use of computers in classrooms was largely limited to isolated activities that relied on the "administrative and instructional skills of the teacher" (Grabe, 1985, p. 36). Furthermore, Grabe noted that the relationship between computers and America's classrooms was largely dominated by worksheet-making programs and purchased software packages. Such integration of technology, while easily accessed by teachers, reflected a lack of professional development focusing on methods by which classroom instructors might harness the potential of technology as a transformative educational tool (Grabe, 1985). In short, computer-related pedagogy in the 1980s was strongly instructor driven and isolated from the usual goings-on of classrooms, with teachers controlling the manner in which students interacted with computers.

This trend of teacher-controlled computer use divorced from the school day existed in spite of recommendations against such pedagogical approaches. In 1980, the National Council of Teachers of Math (NCTM) issued *An Agenda for Action* which, in 1989, would be codified into national math standards (Klein, 2003). The 1980 report referenced throughout the value of the use of technology in math classrooms, and recommended changes in pedagogy to emphasize the development of students' critical thinking skills and increase problem solving abilities. Specifically, technology in the form of handheld calculators was advocated in the hope that it would make problem solving available to all students, even those without basic skills (Joint Committee of the Mathematical Association of America, & the National Council of Teachers of Mathematics, 1980).

Interestingly, the NCTM's report called for a radical departure from classroom practices of the time, recommending a decreased emphasis on students carrying out basic exercises such as paper and pencil calculations with the rationalization that the calculator had reduced the demand for such techniques. A later statement by the California Mathematics Council, an affiliate of the NCTM, justified this shift based on 21st century skill-development reasoning: a researcher had found Fortune 500 companies placed a person's ability to carry out mathematical computation by hand at the bottom of a list of desirable employee skills, while problem solving abilities were highly desirable (Klein, 2003), justifying the end of paper-pencil calculations.

The 1990s. The 1990s marked the beginning of the boom in classroom technologies, including laptop computers. By the late 1990s, the literature was rich with studies focusing on changes in the frequency of computer use in K-12 classrooms across the USA. A number of federal policies encouraged this boom in schools' acquisition of hardware and increases in connectivity, and educational councils began to focus more explicitly on the potential role of technology in student learning.

The most notable movement that gave computers in schools a boost was the 1996 NetDay event developed by John Gage, then of Sun Microsystems. NetDay called on tech companies in California to commit resources to schools (as well as other community-based organizations such as libraries and clinics) so that they could connect to the Internet (Olsen, 2008). Approximately 50,000 volunteers, including President Bill Clinton and Vice President Al Gore, spent a day in California's public schools installing the infrastructure to ensure internet access (NetDay, 2003-2014). In his NetDay speech, Clinton praised the event as a demonstration of the power of community in improving America's schools by ensuring a bright future that would be achieved by guaranteeing students access to information technologies (William J. Clinton Foundation, 1996), and shortly thereafter the event spread nationwide (The White House, 1997).

Consequent to NetDay was Clinton's approval of a financing journey in the form of the launch of a $2 billion five-year Technology Literacy Challenge Fund, with $200 million approved by Congress in 1996. Early in 1997, an additional $57 million was awarded, and 24 states and territories benefitted in total. Clinton's four goals for technology and education were as follows:

- Provide all teachers the training and support they need to help students learn using computers and the Internet;

- Develop effective and engaging software and online learning resources as an integral part of the school curriculum;
- Provide access to modern computers for all teachers and students; and
- Connect every school and classroom in America to the Internet by the year 2000. (The White House, 1996)

More than being a solid plan, this initiative was meant to catalyze the nation's movement toward the use of computers in the educational process. One effect of the 1996 NetDay event and the Clinton Administration's policy support was an emerging understanding that the United States was hurling toward a future in which technology was to become an inextricable part of the educational terrain, and NetDay was a clear indicator of the extent to which entire communities were becoming vested in the technologization process (NetDay, 2003-2014).

In light of this evident shift, the Educational Testing Service's (ETS) Policy Information Center issued a 1997 report on the state of technology in schools with the intent of creating a baseline of information from which change might be tracked (Coley, Cradler, & Engler, 1997). In consideration of the National Science Foundation's (NSF) statement in 1996 that technology used properly makes learning more lasting and effective for all students (Klein, 2003), the ETS's findings elicited mixed reactions simply because the portrait of educational technology use in the United States at the time was inconsistent across race, gender, and socio-economic classes. The findings of the ETS study reported that 98% of schools had at least one computer in the building, with 85% reporting the presence of multimedia computers; however, the average ratio of students to computers was 24 to 1, which was five times the Department of Education's (DOE) recommendation at the time (Coley et al., 1997). This ratio, however, was not equitable across all states, economic classes, grade levels, or races. While students in poor and high-minority schools generally reported less time using school-supported technology, students who were identified as Title I indicated almost daily use of computers as did students who were Black and Hispanic (Coley et al., 1997). Despite this promising statistic, 60% of fourth graders, 51% of eighth graders, and 37% of twelfth graders included in the study said that they had never used a computer for school work.

The ETS study highlighted inequities in classroom computer use in the 1990s and now allows a retrospective look at other patterns of use in the United States at a time when the 21st century skills movement was just beginning to gain steam. In 1997, females were more likely than males to have had word processing experience and less likely to have had coursework or experience in computer literacy and computer programming; additionally, females were less likely to use computers to solve math and natural science problems (Coley et al., 1997). Similarly, the researchers found that students of both genders from minority groups were less likely to use computers to solve problems in math and natural science or to use computers in English classes. Minority students also featured lower levels of computer literacy despite the finding that they were more likely to have courses in data processing and computer programming.

The 2000s. In the 2000s, researchers increasingly explored the notion that digital classroom technologies might be essential drivers in accelerating forward momentum for school change. At the same time, however, computers were being vilified for the changes they might bring to education. Perhaps because of generational, cultural, and educational differences, teachers were found to demonstrate differing levels of willingness to embrace classroom technology, with some educators demonstrating that they were eager adopters and others indicating reticence at using devices (Oliver & Corn, 2008; Texas Center for Educational

Research, 2008). In response to the NCTM report discussed previously, Richard Askey (2001) suggested that technology might act as a smoke screen and criticized the NCTM report for failing to state that America's math teachers lacked sufficient mathematics knowledge to properly teach math. Technology was acknowledged as a tool that could be used to cover teachers' content-knowledge and pedagogical shortcomings and allow students to engage in "just about everything except solving the problem" (Finn, Julian, & Petrilli, 2006, p. 111).

In fact, as the decade proceeded, researchers began to suggest that there was more to effective classroom technology use than simply having the devices in the classroom. Curriculum, teacher training and professional development, community buy in, staggered introductions, and detailed operation plans all were explicated as necessities in rolling out and sustaining technology-related initiatives. In 2010, Weston and Bain published the finding that schools that are most successful with technology implementation were not those that had striven to replicate traditional models of education through computers but had gone beyond simple adoption of digital technologies in their bids to educate for the future and made strides in creating a new way of conceptualizing education (Weston & Bain, 2010).

In general, stakeholders by the 2010s were recognizing that instituting a technology initiative was far more complex than buying computers and asking teachers to incorporate them into daily instruction. Furthermore, computers were not facilitating the automatic success that might be expected of a highly-funded 21st century tool. Instead, technology implementation was found simply to amplify the positives and negatives within a school or district (Goodwin, 2012). This issue has been exemplified by large-scale failed technology debacles such as occurred in Los Angeles in 2013, in which the school district's iPad initiative was fraught with accusations of corruption, students were unable to access Pearson-supplied content, and instructors lost instructional time while trying to deal with device-related issues (Lapowsky, 2015; B. Lucas, interoffice correspondence, March 19, 2015). The media coverage that arises out of such failed endeavors can be brutal, and initiatives can come to be regarded as the educational equivalent of a money pit from which no one will benefit (Lapowsky, 2015).

As this history section has shown, classroom digital technology has proceeded through phases to bring schools and researchers to where they are today in relation to classroom computers. In the earliest days of educational computers, research focused on how computers might be used in classrooms. The concern that permeated the age—that people might be replaced by computers and robots—also permeated the literature on classroom computers. In the 1970s and 1980s, debates focused on the role of the computer in shaping students' learning and supporting classroom pedagogy. At their heart, however, these debates were the beginning of the 21st century skills movement and the conceptualization of American public schools as progressive institutions in which something more than content might be taught. In dialoguing on the role of computers in the classroom, Suppes and Papert were in a sense asking whether America's schools might be institutions that could deliver more than drills on content knowledge. As computers and connectivity became more widely available and affordable in the 1990s, greater expectations were transferred to schools in terms of helping students to develop ICT skills.

The 1990s and early 2000s were years marked by increasing research on the academic effect of computers in classrooms, although as digital technologies became more ubiquitous in American classrooms and school districts sought to rationalize spending on technology tools, 21st century learning came to be equated solely with technology-rich classrooms (Bellanca & Brandt, 2010). Especially in relation to ever more complex communication requirements and the increasing importance of data filtration, 21st century skill development in relation to digital communication tools would seem essential in a classroom aiming to educate for the future (Dede, 2009). The current decade is one in which the scope must be widened beyond academics in order to more fully consider the effects of computers in classrooms that are increasingly complex.

Theoretical Framework

The complexity of modern communication and classroom technology calls for a theoretical lens that reflects and can explain and express an equal level of complexity. Activity theory (Figure 1), which has been described as a powerful, clarifying descriptive tool (Nardi, 1996), offers a way by which each element of a system and those elements' interactions might be interpreted and understood (Méndez & Lacasa, 2015). The weakness in many theoretical models that aim to analyze the processes involved in system interactions is that the invisible processes—"troubles, interactions, and sideways interactions"—are missed, lending an artificial streamlined appearance to the empirically determined outcomes (Engeström, 2008, p. 23). Activity theory accounts for and embraces those interactions, lending greater richness to a system-based study.

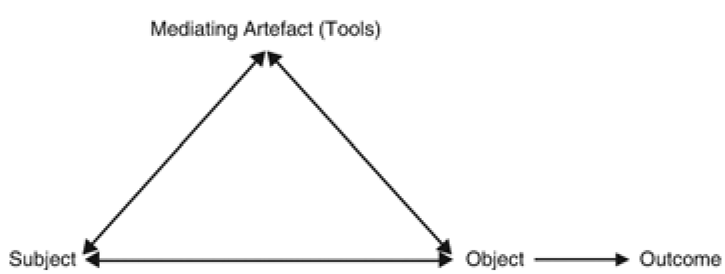

Figure 1. First generation activity system. Adapted from Mind in Society—The development of higher psychological processes (p. 40), by L. Vygotsky, 1978, Cambridge, MA: Harvard University Press. Reprinted with permission (Open Access).

The roots of activity theory lie in the works of Vygotsky (1978) who, with his theory of the zone of proximal development, pointed out that people should not be judged according to what they can do alone but according to what they can accomplish with the help of a more experienced other. Engeström used this concept in an expanded sense to explain the potential that exists when two activity systems contact one another (2008). His earliest iteration of activity theory (as shown in Figure 1), however, drew heavily from Vygotsky's concept of mediation, which forwards the theory that people's behaviors are mediated by the objects that surround them (Engeström, 1999b). This first-generation expression of activity theory does not account for others in any explicit way and so is limited in its ability to explain interactions in larger systems.

Like the 21st century skills movement, activity theory grew out of the shift in political and economic systems of the 1980s and 1990s (Engeström, 1999); therefore, many of the characteristics of the times and the theory are strongly related. In particular, activities manifest from below as opposed to being attributable to persons of power, change occurs unexpectedly and escalates rapidly, the individual cannot be viewed separately from socioeconomic structures, and contradictions and disagreements cannot be viewed as signs of weakness but as essential to dynamic outcomes (Engeström, 1999).

Engeström's earliest version of activity theory views a system as a dynamic unit in which six elements interact with one another—the subject is the group of individuals involved in the activity; the object is the motivating influence that drives participants' participation in the activity; artifacts or tools are the physical or psychological items that mediate activity between the subject and object; the community is the social or cultural group to which subjects belong with rules that regulate behavior; and the division of labor defines how tasks and responsibilities are shared among the elements of the system as they participate in the activity (Cole & Engeström, 1993). To state the theory succinctly, an activity system is composed of "the individual practitioner, the colleagues and co-workers of the workplace community, the conceptual and practical tools and the shared objects as a unified dynamic whole" (Engeström, 1991, p. 267), and the theory aims to explain how people within the systems come to the outcomes that they do.

As illustrated in Figure 2, the perspective of a person participating in an activity is affected and driven not only by the participant but also by the tools mediating the activity, the community involved in the activity, the rules that govern that community, and the division of labor between all involved in the action; in addition, as mediation is bidirectional, the processes will affect the mental processes of all individuals involved in the activity (Bellamy, 1996).

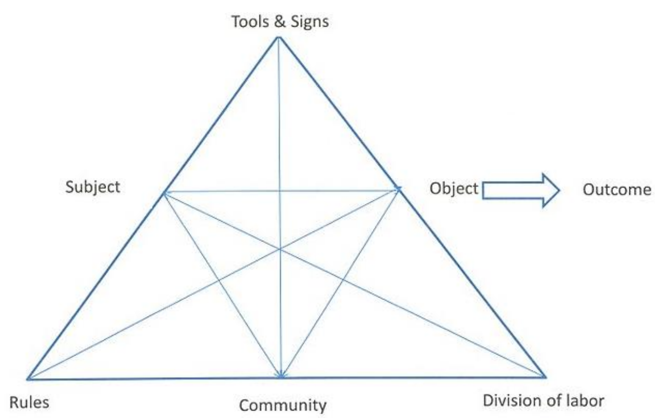

Figure 2. The socially distributed activity system. Adapted from "A cultural-historical approach to distributed cognition" (p. 8), by M. Cole & Y. Engeström, 1993, New York, NY: Cambridge University Press. Reprinted with permission (Open Access).

Invariably, tensions, contradictions, and interactions occur between the elements that create an activity system, but those tensions are what drive the outcome in activity theory.

One powerful aspect of activity theory is its ability to support the examination of transformation processes triggered by complicated system-based interactions. The theory is multidisciplinary and international and acknowledges that human interactions are multi-voiced, multifaceted, and rich (Engeström, 1999). Illustrating this point, Engeström's first activity theory work was based on janitorial staff—a group of laborers who generally are dismissed for working in a profession that is believed to hold little opportunity for cognition. However, through an activity-theory-based examination of their workplace, the researchers concluded that “every kind of work requires complex thinking, problem solving, and learning” (Engeström & Glăveanu, 2012, p. 515). A later longitudinal study of the contradictions and connections within a Finnish children’s health care setting highlighted the constant dissolving and reforming of connections, or “knotworks”, that occur as objects of activity are renegotiated over time (Engeström, 2000). Through artifact-mediated actions, multiple parties that are involved in any activity system work in pursuit of outcomes, shift their desired outcomes, and find their outcomes in conflict with the outcomes of others constantly. The layered team formation and “knotworking” that coexist as a result of these tensions are what make activity systems so dynamic and also what can facilitate unexpected change.

Because activity theory supports the examination of dichotomous systems that are at once traditional and progressive, it has proven an excellent lens through which to study educational institutions. The meeting place of two or more systems’ outcomes produces a third space of identity and/or community which has been explicated extensively in post-colonial literature by Bhabha (1984) and can be conceptualized most simply as hybridity of thought or culture which enables other positions to emerge (Rutherford, 1990). That third space represents the other position that emerges from tensions between the outcomes of two systems. It is anticipated that, in the current study, the tensions that are addressed in the activity systems studied (i.e. one-to-one initiative schools) will result in 21st century skill development.

The Evolution of 21^{st} Century Skills

In 2012, Grant Lichtman, climbed in his Prius to drive across the United States and back to visit over 60 of America's schools. His aim was to see firsthand what was happening in the world of education. In 2013, at a Denver TEDx event, he described his observations as follows:

> Our schools are becoming relevant. They're crossing those boundaries of subject and allowing schools to connect the dots in so much more authentic ways that engage them. We're becoming self-correcting. We're taking time. Students and teachers are taking time for authentic reflection during the day…and we're taking the time to think about the balance between constant innovation and…strengths and cores of tradition that make us strong. [6:11]

Throughout his talk, Lichtman touched many times upon the characteristics of what has become an educational buzzword—21^{st} century skills.

These 21st century competences or skills, were characterized by Voogt and Pareja Roblin (2012) as being transversal, or relevant across different fields of work and study; multidimensional; and associated with skills and behaviors that "represent the ability to cope with complex problems and unpredictable situations" (p. 300). This skill set has also been defined as inclusive of dozens of soft skills, including adaptability and self-management (Bybee, 2009), problem solving (Kaufman, 2013), and an artful combination of career skills and content mastery (Lemke, 2002). The application of such skills in the classroom would perhaps bring about a change in educational emphasis where teachers focus on what students can do with knowledge rather than on what units of knowledge they possess (Silva, 2009). Frameworks developed in the United States and abroad reflect the international nature of the discussion of skills for a rapidly changing world. The frameworks presented below are considered major 21st century skill frameworks (Voogt & Pareja Roblin, 2012).

21st Century Frameworks

In 2012, seeking to determine the horizontal and vertical intersections between different definitions of 21st century skills, Voogt and Pareja Roblin analyzed eight major 21st century skills frameworks: the EnGauge framework (2003); the International Society for Technology in Education (ISTE) framework (2007; 2016); the Partnership for 21st Century Learning (P21) framework from Battelle for Kids (2019); the Key Competences for Lifelong Learning, which is a European Union (EU) reference framework (2007); the Organisation for Economic Co-operation and Development (OECD) 21st Century Skills and Competencies for New Millennial Learners; the Assessment and Teaching of 21st Century Skills (ATC21S) framework (Cisco, Intel, & Microsoft, 2010); the United Nations Educational Scientific and Cultural Organization (UNESCO) Information Communication Technologies Competency Framework for Teachers (ICT-CFT) (2011), and the National Association of Educational Progress (NAEP) framework (2012).

The EnGauge Framework (2003). EnGauge is a Web-based framework developed by the North Central Regional Educational Laboratory (NCREL). One of 10 regional education laboratories in the United States, NCREL serves a handful of Midwestern states but publishes information that is applicable to and useful in many learning contexts (NCREL & Metiri Group, 2003). Its mission is to improve American schools through research and evaluation, training and the provision of technical assistance, seminars for education professionals, and through product development (Education World, 1997). In short, EnGauge aims to develop schools into "high-performance learning organizations" (2003, p. 2). Literally framed by academic achievement, the

EnGauge identifies essential skills that are covered by 21st century learning—digital-age literacy, inventive thinking, effective communication, and high productivity.

The International Society for Technology in Education (ISTE) framework (2007, 2016). ISTE, through the ongoing solicitation of feedback from stakeholders from the 50 United States and 50 countries, promotes their framework as one which provides guidance for the development of in-depth, digital age skills. The declaration that the framework is intended to act as a “dynamic, useful guide supporting and deepening many other initiatives” suggests the interconnectedness of a global society (ISTE, 2016, p. 11). The interconnected elements that constitute digital age learning are communication and collaboration, creativity and innovation, technology operations, digital citizenship, critical thinking, and research and information.

The Key Competences for Lifelong Learning. The Key Competencies for Lifelong Learning (European Union Education and Culture Directorate General Lifelong Learning Programme, 2007) is not a framework but a set of recommendations for education that aim to provide a straightforward conceptualization to help equip EU citizens with skills by which they can adapt to a rapidly globalizing world. The document, which is a joint work of the European Commission and the Member States within the Education and Training 2010 Work Programme aims to, among other things, provide a guide for community-level institutions to educate in order that citizens can thrive in a knowledge society. The focus throughout the document is on essential knowledge, skills, and attitudes to be developed.

Partnership for 21st Century Skills (P21) framework. P21, now a part of Battelle for Kids, was founded in the United States in 2001 by members of the business community, leaders in education, and policymakers to encourage discussion of the skills necessary for future success (Battelle for Kids, 2019). The P21 framework, which pictorially reflects the elements that constitute a 21st century skills-supporting institution, is actualized as a blocky arch which incorporates necessary student soft skills and academic content with educator imperatives and institutional supports. The skills sets, which have come to be known as “the Cs”, include creativity, critical thinking, collaboration, communication, life and career skills, information and communication technology (ICT) skills, and content. Hundreds of educational agencies and organizations have adopted the Battelle for Kids P21 Framework to guide the implementation of 21st century skills and are working toward incorporating the skill set into their curriculum and professional development (Battelle for Kids, 2019).

21st Century Skills and Competencies for New Millennial Learners of the Organisation for Economic Co-operation and Development (OECD). The OECD’s 21st century competencies belong to three dimensions—information, communication, and ethics and social impact—with the goal of providing a conceptual framework for the Programme for International Student Assessment (PISA) test (Voogt & Pareja Roblin, 2012). A secondary aim of the framework is to provide educators, policy makers, and researchers with guidelines to educate in the knowledge economy of the 21st century (Ananiadou & Claro, 2009). The information dimension of the OECD framework encompasses what a student can do with digital information once it has been collected and organized, including communication, analysis, and summarization. Creativity and problem solving are considered necessary for dealing with information effectively, and social impact and responsibility are essential skills (Ananiadou & Claro, 2009).

Assessment and Teaching of 21st Century Skills (ATC21S). The ATC21S framework, sponsored by Cisco, Intel, and Microsoft and implemented internationally with individuals from more than 60 research institutions, provides an operational understanding of 21st century competencies (Cisco, Intel, & Microsoft, 2010). The ultimate goal of the project was to provide information to facilitate the creation of 21st-century skills-appropriate assessment tasks (Voogt & Pareja Roblin, 2012). The framework is marked by interconnected bubbles which describe new ways of being in a world marked by immense and rapid changes (Cisco, Intel, & Microsoft, 2010). The ways of thinking, working, and living in the world are facilitated by technology tools for working.

The ICT Competency Framework for Teachers (ICT-CFT). The ICT-CFT is a UNESCO initiative (2011) that acknowledges the rapidity with which technology has been incorporated into learning environments throughout the world. The framework aims to respond to this change in education by providing a resource to guide educational systems at a federal level, as well as teacher education programs, professional development providers, and working teachers in developing comprehensive standards for ICT competency policies and standards. While the general focus of the document is on ICT and the way in which teachers might harness its power for promoting learning, the framework also serves a second purpose—to illustrate how "teacher-education, particularly in developing countries, can increase the effectiveness of teachers and enable school students to become engaged and productive members of the knowledge society" (UNESCO, 2011, p. 5).

Technological Literacy Framework for the 2012 National Assessment of Educational Progress (NAEP). The NAEP framework focuses on technological literacy in grades 4, 8, and 12, with a "probe" assessment at grade 12. The framework focuses broadly on technology defined as all products, processes, and systems that support human needs and was supported in its development by a broad base of stakeholders, including scientists, engineers, and public education officials (NAEP, 2009).

Of these eight frameworks, three were developed under the guidance of international agencies (the OECD, EU, and UNESCO) while five were developed through the efforts of private organizations, suggesting the concern of many stakeholders regarding 21st century skill development. However, somewhat worrying is that the 21st century skills movement has been disassociated from the world of teachers and students as they have been largely absent from the development of these frameworks and the discussion of their impact on curricular development, institutions, teachers, and students (Voogt & Roblin, 2012). Acknowledging this shortcoming in 21st century skills frameworks is essential in this dissertation as this absence of educators' voices suggests that the frameworks may be inapplicable to the reality of America's classrooms. This study seeks, in part, to determine whether this phenomenon is in fact at work and whether stakeholders perceive 21st century skills development in America's high schools.

In an analysis of these eight major frameworks, Voogt and Pareja Roblin (2012) found a great deal of alignment and consensus between definitions of 21st century skills and competency recommendations, the need for teachers to play a central role in their implementation, and the central role of ICT in creating 21st century learning environments. In determining the importance of competencies, however, there are still many discrepancies, including a lack of consensus on concrete methods for implementation and assessment tools and procedures to measure successful implementation (Voogt & Pareja Roblin, 2012). Although Anadiadou and Claro (2009) found that most OECD countries had adopted 21st century competencies as part of their curricula, the United States, which is an OECD country, has adopted them inconsistently because of the diffused power of the federal government and the inconsistent acceptance of the Common Core State Standards (CCSS). The State of California, a CCSS adopter, has acknowledged that students' success with their state standards goes hand-in-hand with 21st century skills (Digital

Chalkboard, 2015), suggesting that curricular approaches are not entirely divorced from the federally-recommend CCSS or the 21st century skills that may be touted in schools and school districts.

Of greatest concern in the current project are areas in which 21st century skills frameworks most often converge—digital literacy, communication, creativity/innovation, and collaboration. Although Voogt and Pareja Roblin (2012) identified other common 21st century skills in all major frameworks, this study is restricted to the four areas mentioned above, as well as content mastery and critical thinking, both of which emerged as strong themes during qualitative data collection. As discussed in this section, 21st century skills can be defined in a multitude of ways. Thus, it is important to keep in mind that, for the remainder of the study, when the term "21st century skills" is used, what is being discussed are digital literacy, creativity/innovation, communication, collaboration, content mastery, and critical thinking.

The Development of the Idea of 21st Century Skills

By 2010, perhaps because of the proliferation of education-related information on the Internet, the growth of internet connectivity and increasing ubiquity of mobile devices, or the ever-expanding media coverage of international metrics of nations' educational achievement, global education reform had become something of an international obsession. In general, global education reform is outward looking, and educational institutions aim to transfer innovation from outside entities (including businesses) to the educational world (Sahlberg, 2011). Structural reforms related to education, which were the focus of the past and were concerned, for example, with overhauling curricula, physical buildings, and systems, had been replaced by reforms related to the quality and relevance of education (Hargreaves & Shirley, 2008). The 21st century skills movement as seen in the previous section is a product of this method of reform as the movement is derived largely from the economic and business worlds. As an educational interest in 21st century skills has developed, it has increasingly focused on teacher training, technology-assisted teaching and learning, and the development of basic competencies as common priorities (Sahlberg, 2011).

To understand the current problemitization of 21st century skills, it is necessary to examine the theory that forms the basis of the skills, the history of the development of the 21st century skills movement, and the relationship between institutions of learning and the non-educational sectors of society. This focus is necessary because the idea of skills for the future arose from the fields of sociology, medicine, and economics among others before finally coming to rest as an educational concern.

Theoretical foundations. The theoretical underpinnings of the 21st century skills movement lay in the ebb and flow of social and economic movements that dominated the academic landscape of the second half of the 20th century, including Touraine's post-industrialism (1971), Drucker's post-capitalism (1993), post-modernism, and egalitarianism (Fogel, 2000). These four movements each have implicitly influenced the 21st century skills movement and, therefore, education as well. This collection of writings, taken as a whole, reflects the sense making that was occurring as the world's economic systems were undergoing rapid changes necessary for the future success of industry in light of developments of the information age.

Post-industrialism. In 1971, the term post-industrial society was established by Alain Touraine, a sociologist who sought to provide a guide to assist with the comprehension of societal transformations (Kivisto, 1980). Touraine's conceptualization of post-industrialism was equivalent to the transition from agrarian to industrial society and was marked by a transformation away from a society which was defined by “the effort to accumulate and anticipate profit from directly productive work” and toward one in which such motivations no longer hold centrality (Kivisto, 1984, p. 357).

The term post-industrialism was popularized in the English language by Daniel Bell (1976), a sociologist at Harvard University. Bell expanded on Touraine’s notion of post-industrialism, framing it as a massive change already underway as the world headed into the final years of the 20th century. Of specific concern was the changing nature of occupational distribution in which people’s place of work would not matter as much as what kind of work they would do, suggesting that that work would be divorced from a brick-and-mortar place of employment (Bell, 1976), and promising to upend traditional notions of labor and economy.

These essential elements of the theory of post-industrialism contribute one aspect of 21st century skills rhetoric: in a world where economic systems no longer are structured solely around the manufacture and provision of goods but have moved toward a system where communication is the most important medium of exchange (Kivisto, 1984). In this world, traditional notions of what constitutes learning must shift toward a new set of competencies, including a flexible knowledge base and communication skills. In the 21st century skill set of concern in this study, Touraine and Bell’s theories have contributed a justification of validity based on a shift away from an industrial manufacturing base and toward a strong knowledge base, leading to Drucker’s theory of post-capitalism.

Post-capitalism. A second theory arose in the 1980s to contribute another element of what was to become 21st century rhetoric: post-capitalism. A post-capitalist society is one in which capital and natural resources do not constitute the most important economic resources—instead, the basic and most important economic resources are knowledge and information, and wealth is primarily created from those two things (Huibin & Dirlik, 2008); Peter Drucker termed this society a “knowledge economy” (1988). After the fall of Communism, Drucker claimed that the post-capitalist society had replaced both Communism and capitalism, and that the world was heading toward a post-sovereign state in which knowledge and information would transcend borders and eventually lead to a dissolution of physical nation states (Huibin & Dirlik, 2008).

According to Drucker (1988), competent laborers within a post-capitalist society, termed “knowledge workers”, know how to leverage their knowledge to productive use. Unlike Touraine and Bell, Drucker directly addressed the role of education systems in creating knowledge workers—equitable and accessible learning opportunities must permeate society and, for that reason, learning to learn is an important skill that must be imparted; along with the development of higher order thinking skills, schools must impart substance (content) and processes (soft skills). Technology was also identified as playing an important role in a post-capitalistic society, but only insofar as it could be used to trigger changes in the substance, content, and focus of schooling (Drucker, 1988).

To the current discussion of 21st century skills, Drucker, through post-capitalism, has contributed the concept of leveraging knowledge over the mere acquisition of knowledge. In addition, post-capitalism encourages the importance of collaboration skills and the ideals of meta-learning, equity and easy accessibility in face-to-face and virtual educational settings. The proposition that technology could play a transformative role in education, while not originating with Drucker, gains justification and support through his theory of post-capitalist society and the changes that are occurring in the world.

Post-modernism. Although the idea of post-modernism has been in use for nearly a century, the term first appeared in print in 1926: “it is not easy to narrate post-modernity”

(Bauman, 1992, xxiv). The ambiguous, complex, hyperbolic, and contradictory way of thinking that post-modernism has become (Thorpe & Holt, 2008; Inglehart, 1997) nearly defies clear explanation in a chapter such as this one where it is not the main focus of the work but just a tiny piece of a larger whole. However, a discussion of post-modernist thinking, especially as it relates to education and knowledge transmission, is essential in a discussion of 21st century skills because post-modernist thought has leant 21st century skill rhetoric its focus on educational institutions as pragmatic skill builders rather than ideal developers, as has been the model for education since the Enlightenment (Bauman, 1992; Lyotard, 1984).

Post-modernism, according to Bauman (1992), is in part a backlash against the perceived excesses, presumed predictability, and linearity that go with modernism. Jean-François Lyotard, a French philosopher and sociologist, equated post-modernism with post-industrialism, but the two philosophies vary enough in complexity and their relationships to 21st century skills that they are treated as separate entities in the current work. To illustrate more clearly, a post-modern world has been described as having specific characteristics and is marked by decentralized power; a flexible workforce that can facilitate production rather than carry out production; the search for reality aided by socially and culturally constructed tools, and borders, whether physical, political, or abstract, which are permeable and constantly renegotiated and reconstructed (Grbich, 2004). In a post-Communist world largely absent of a society built upon a utopian vision, post-modernism fills a void that has opened around the issue of the route to emancipation and fulfillment within the confines of the human condition (Bauman, 1992).

While Grbich's writing explains postmodernism from a more global perspective, Lyotard (1984) explored post-modernism and its effect on knowledge. In the world of post-modern knowledge, education has been marked by a movement toward functionality; thus, the development of skills that facilitate the manipulation of knowledge, data, and ideas has come to supersede the simple transmission of knowledge in educational institutions—knowledge for the sake of knowledge is an unrealistic mantra in post-modernism. As such, the transmission of knowledge, which is no longer a practice limited to a circle of intellectual elites, should be regarded as a practice that is not only constituted of bits of data but also include all of the procedures that increase one's ability to "connect the fields that have been jealously guarded from one another by the traditional organization of knowledge" (Lyotard, 1984, p. 52). The model of content-specific, departmentally-segregated knowledge, in post-modern thought, is an antiquated and dysfunctional notion that is asynchronous with a world in which information consumption has become matter of course (Bauman, 1992). In the current study of 21st century skills and their relationship to one-to-one initiatives in high schools, post-modernism can be regarded as the underpinning philosophy that most strongly supports the general vision for education forwarded by the various 21st century frameworks.

Egalitarianism. Egalitarianism is a deceptively simple term, with its central tenet being that all members of society should be treated equally. However, the interpretation of what can be construed as equal varies widely. O'Leary (2007), for example, pointed out that, while egalitarianism underpins both Communist and capitalistic political systems, the actual implementation is highly divergent. In the American system, all are supposed to be equal under a blind legal system but not all are guaranteed equal access to material wealth; in contrast, the discourse of Communism states that all resources are supposed to be shared equally (O'Leary, 2007), and that balanced resource distribution equates with egalitarianism. As with post-modernism and the difficulty that is associated with defining it clearly, an equal challenge is faced with egalitarianism as an interpretation of what exactly constitutes equality in any given situation fluctuates according to the political, economic, cultural, or social situation in which it is being applied.

Egalitarianism in one form, as stated previously, is an ideology that is central to American thought and is based in the rhetoric of the country's earliest government writings. The American *Declaration of Independence* states, "We hold these truths to be self-evident that all men are created equal", lending an egalitarian air to the American culture. America's education system, as it has developed, has been steeped in many elements of egalitarianism (Goldin & Katz, 2008). It should come to no surprise then that Robert Fogel, who was awarded the Nobel Prize in Economic Science in 1993, calls egalitarianism "the national mantra", because it permeates so many levels of American society and is espoused by both institutions and individuals at those levels (Fogel, 2000).

Despite the national mantra and the centuries-old tradition of egalitarianism, the United States is in the midst of "an egalitarian crisis" for a number of reasons (Fogel, 2000; Goldin & Katz, 2008). At a societal level, the crisis stems from technological changes that periodically transform America's economic and social landscape, awakening to new conceptualizations of egalitarianism (Fogel, 2000). Throughout most of the 20th century, people achieved egalitarian living standards through the acquisition of durable material goods such as cars, houses, and appliances—these items were markers of the American dream and ownership signified possessing an equal share of it (Fogel, 2000). The period in which we are currently living is a departure from equality marked by "keeping up with the Joneses" on a material level, which Fogel has labeled "immaterial egalitarianism".

Immaterial egalitarianism is marked by the equal (and unequal) distribution of people's abilities to become self-realized, evolving away from hierarchies and their demands which remain divorced from the self and more toward self-guided and self-situated learning and development (Fogel, 2000). As opposed to “old egalitarianism”, which was prevalent in the 20th century and conceptualized equality as a standard achieved through economic security and the redistribution of wealth, “new egalitarianism” focuses on widening opportunities to achieve security (Diamond & Giddens, 2005).

The 21st century movement, especially as it is supported by digital devices in one-to-one initiatives, can be viewed as a movement toward further egalitarianism within schools. When the two movements are overlaid, they support immaterial commodity development since one-to-one initiatives level the learning-based playing field, and the 21st century-skills focus encourages the development of soft skills, which may allow students to enjoy more equal future access to the knowledge economy. These two areas taken together consequently will determine success in competitive global markets (Fogel, 2000).

Discussions of 21st century skills have evolved from theories that have arisen and gained strength in the post-Communist world. New ideas about shifting economies, new conceptualizations of the meaning and value of knowledge, and the pragmatic value of those ideas to education have acted as the gently guiding undercurrents of the 21st century skills movement in education (Table 1).

Table 1

Alignment of 21st Century Skills with Theories and Work-Based Ideas

Authors, year	**Theory**	**Work-Based Ideas**	**Relationship to 21st century education**
Bell, 1976; Kivisto, 1984; Touraine, 1978	Post-industrialism	Communication is the most important medium of exchange, superseding manufacturing	Communication is an essential skill to be taught; Learning is not necessarily related to a brick and mortar institution
Drucker, 1988; Huibin & Dirk, 2008	Post-capitalism	Laborers are "knowledge workers" Knowledge and information transcend borders	Learning to learn and higher order thinking skills are highly important; Knowledge should be leveraged rather than simply acquired
Bauman, 1992; Grbich, 2004; Inglehart, 1997; Thorpe & Holt, 2008	Post-modernism	A flexible workforce is necessary to facilitate rather than carry out production	Education must focus on pragmatic skill building before ideals; Collaboration is vital; Content-specific teaching is antiquated
Fogel, 2000; O'Leary, 2007	Egalitarianism	As the workforce evolves away from traditional hierarchies, they must become self-guided in developing new skills	Immaterial commodity development (e.g., knowledge and skills) must be supported in order for students to access the knowledge economy in the future

Thus far, this literature review has focused on the theoretical aspects of the 21st century skills movement. The following section aims to explore the impetus for moving the 21st century skills into educational settings.

Moving Toward 21st Century Skills

In the early 2000s, concurrent writings from the fields of economics and business made similar claims about workplace needs being out of sync with America's educational system. Complex cognition, communication, the ability to synthesize and manipulate information (Levy &

Murnane, 2004), creativity, and empathy (Pink, 2005) all were identified as essential skills for future workplaces, but none were considered mainstream subject matter for study in high school. As one business owner stated in reference to what might be taught to students at the secondary level to prepare them for the work place, "We can teach [employees] technical stuff, but we can't teach them how to ask good questions—how to think…You have to know how to work well with others. But you also have to know how to engage customers" (Wagner, 2008, p. 20). The new American workplace, with focus on service over production, would be a place requiring the aforementioned skills and, in addition, computer-literate individuals with scientific skills and abilities to learn and comprehend ideas and values (O'Toole & Lawler, 2006). The importance of soft skills is ubiquitous in the literature of the first decade of the 21st century, and the inaction of America's education system in responding to these new needs began to garner increasing attention resulting in studies of skill development in high schools toward the end of the decade.

A need for soft skills. At the turn of the century, the impetus for a shift toward 21st century skills in schools was clearly articulated by Alan Greenspan. Remarking to the U.S. Department of Labor on the changes occurring in the United States economy, the Chairman of the Federal Reserve stated, "Workers must be equipped not simply with technical know-how, but also with the ability to create, analyze, and transform information and to interact effectively with others. Moreover, that learning will increasingly be a lifelong activity" (2000, para. 11). Greenspan's comments reflected a political and economic movement that was already underway in the United States, and his speech was followed by the initial developments of the frameworks discussed in the previous pages and, through the early- and mid-2000s, numerous studies, white papers, and books examined the state of the American job market, the direction in which it was anticipated to head, and the possible reasons that America might be left behind in the global race toward a new way of working and thinking.

An examination of the literature has revealed that the 21st century skills discussion as it relates to and is applied in education was, until the mid-2000s, a piecemeal, limited venture, and it was not until the middle of the first decade that empirical studies of 21st century skills in education began to emerge in the literature (Achieve, Inc., 2005; Friedman, 2006; Pink, 2005; O'Toole & Lawler, 2006; Reich, 2000). However, as 21st century skills were not an articulated part of America's basic education landscape, the absence of education-specific 21st century skill-based research before the mid-2000s is not surprising.

A lack of workplace and college preparation. As the 2000s opened, a number of writings in economics and politics contributed to the general discussion of abilities for a new century, with most of them focusing on job skills and their implications for leadership. In 1995, for example, nationally-recognized leadership gurus noted that, due to advances in information technology, the hierarchical structure of "power has gone to the people—the clients" and highlighted the necessity for a change in leadership that was becoming evident in situations where "so-called modern management techniques were designed to support a master-slave world" (Kouzes & Posner, 1995, xvii). In this same work, the authors recognized the benefit of education in encouraging this conceptual shift, but only to the extent that the college educated might expect to find employment easily while those with high school degrees could expect more difficulty in a job search. While Kouzes and Posner presumed a 21st century education to be imparted through a university education, the authors did not explore education for the 21st century outside of the recognition of technology as an essential component.

The literature around 21st century skill development in education quickly evolved in focus, moving away from the recognition of a general need for change in leadership and toward empirically-justified identification of school-based issues that might be contributing to young people's lack of preparation for higher education and the workplace. Three empirical studies with large samples led this exploration. In 2003, 1,723 students, faculty, administrators, and community members in Michigan's Schoolcraft College and 16 community colleges were interviewed and surveyed to determine whether stakeholders recognized the importance of skills necessary to be successful in the 21st century and the presence of skill instruction in the various schools (Sigworth, Hawkins, & Daieth). While most stakeholders agreed that 21st century skills were important for success, there were differences in agreement as to how to assess, learn, and teach those skills; the disagreement manifested itself most strongly between community members and parties involved in higher education. The seeming lack of readiness in high school graduates for the post-secondary world, the authors concluded, might be attributable to disconnects between each group's perceptions of the skills requiring the greatest emphasis, and how best to implement and assess those skills in the classroom (Sigworth et al., 2003).

A second large-scale study with a similar focus sought to determine employers' and university faculties' perceptions of high school students' workplace readiness upon graduation (Achieve, Inc., 2005). In the interview-driven study of 1,487 high school graduates, 400 employers, and 300 university instructors teaching freshmen, findings pointed to the general lack of skills-based preparation imparted by high schools. Specifically, the lack of preparation imparted in secondary programs and low teacher expectations of high school students were found to contribute to young people's lack of readiness for the post-secondary world (Achieve, Inc., 2005).

An analysis of 25 years of research on workplace matters and structured interviews conducted within large and midsize private companies confirmed this mismatch between educationally-imparted skills and business needs (O'Toole & Lawler, 2006). Especially in consideration of the finding that America had positioned itself as the leader in the "unsettling global process of economic and industrial transformation", America's basic education system was viewed as lacking in developing young people's 21st century skills (O'Toole & Lawler, 2006, p. 5). In particular, the study revealed that new educational necessities—communication, computer literacy, scientific skills (i.e. observation, measuring, calculating), understanding others' ideas, and learning to learn—were going largely unaddressed in high schools (O'Toole & Lawler, 2006).

A tiny handful of studies have sought to develop an understanding of the detailed goings-on in America's high schools in order to pinpoint the reason that high school graduates have been accused of lacking soft skills and career and college readiness. One researcher proposed that the global achievement gap was widening as new survival skills were not being transmitted in observed classrooms (Wagner, 2008). Based on hundreds of observations of classrooms in America's most highly regarded suburban high schools, the researcher found that the seven necessary skills—critical thinking and problem solving, collaboration and leadership, agility and adaptability, initiative and entrepreneurship, effective oral and written communication, the ability to access information, and the ability to carry out analyses of information—were being dismissed in lieu of test preparation (Wagner, 2008b). A more current report has taken the discussion of preparation for a new workplace to recently graduated students, 43% of whom indicated that upon graduation they felt ill prepared to use technology in the workplace (Nellie Mae Education Foundation, 2011).

As this section of the literature review has shown, as of the first decade of the 21st century, a new set of skills for a rapidly changing world had been actualized and economically justified, and the idea that they could be taught had entered conversations about classroom instruction. In support of this discussion, computers and other digital technologies have often been forwarded as potential transmitters of 21st century skills, quite likely because they are regarded as tools for a digital age and are often the only material object cited in early literature that might promote necessary skills for a new era (Kouzes & Posner, 1995; Nellie Mae Foundation, 2011; O'Toole & Lawler, 2006). An examination of empirical literature on one-to-one initiatives, activity theory as it has been applied in education, and 21st century skills will follow the section on empirical studies.

Empirical Studies

In the section that follows, empirical research on one-to-one initiatives and 21st century skills will be presented. The initial focus in assembling the review was on intersections between the two areas; however, the two educational phenomena have not happened concurrently, and the research is reflective of that fact in that intersections were not as present as originally hoped or expected. The studies in the section that follows are presented in three subsections. The first subsection focuses on empirical studies related to activity theory. The second section focuses on literature associated with one-to-one initiatives and classroom technologies. The third subsection focuses on empirical studies related to 21st century skill development.

Activity Theory

Activity theory has been used recently to explore relatively new phenomena in education, and researchers have used third-generation activity theory to address the interactions not only of elements within a system, but also interactions between systems. A recent study framed around the third space at the core of third-generation activity theory (outcome$_3$) attempted to capture how Vietnamese teachers took into account traditional and contemporary influences to make non-traditional assessment practices feasible in their classrooms (Thanh Pham & Renshaw, 2015). Vietnam's education system is steeped in Confucian traditions and didactic teaching and assessment models dominate the pedagogical landscape with great emphasis on summative assessments. However, Vietnamese teachers increasingly have been asked to incorporate formative assessments into their teaching and assessment practices. Thanh Pham and Renshaw's study highlighted the tensions that have been found to arise when teachers and students are asked to do things differently, but also noted that doing things differently is often the change that is needed to encourage progress (2015). The researchers noted that changes made were adapted and evolved in response to the classroom culture that already existed, were dependent upon the two teachers and 250 students involved in the study and proceeded according to institutional norms and rules but also according to how the school's principals pushed for the reform.

An example of a development in response to the tension between traditional ways of teaching and modern expectations was the teachers' approach to making assessment more student centered. Using the same multiple-choice tests and procedures that had always been used, the teachers added a communicative element, giving the students the opportunity to dialogue on their test answers in small groups after they had completed the exam. Students could contribute to the debate and change their answers as a result of the discussion before submitting their work for a final grade. In this case, the tensions between the tool, subjects, norms, and community resulted in a new way of being, learning, and assessing in a Vietnamese classroom (Thanh Pham & Renshaw, 2015).

Another education-based phenomenon that has been examined through activity theory is school-university partnering in educator preparation programs in Australia. While recognized as a key component in improving teacher quality, analysis of the effectiveness of such partnerships is limited (Bloomfield & Nguyen, 2015). In their study, Bloomfield and Nguyen noted that the tension that naturally evolves between the desired outcome of the university—a quality graduate—and the cooperating school—a classroom-ready teacher—should be the primary and negotiable focus of the school-university partnership. To wrestle with the resultant tensions head on, the cooperating parties in the study participated in structured discussion workshops for both the supervising teachers and the university academics. This "boundary space" was the material expression of activity theory's outcome$_3$ and provided a useful way forward to strengthen the partnership (Bloomfield & Nguyen, 2015).

The previous two examples have given a brief glance into two different ways that activity theory has been used as a lens to better understand educational settings. What those two examples have not captured, however, is the extent to which activity theory has been used in examining the integration of technology into schools worldwide. Virtual education, distance education, video game use, hybrid classrooms, and general laptop integration have all been studied through the lens of activity theory as explained below.

In the realm of educational technology, activity theory has been used to examine the contradictions between activity systems of virtual and physical high school classrooms (Murphy & Manzanares, 2008). Through an activity theory-based examination of the two settings' systems, researchers found contradictions related to time and workload, the use of direct messaging versus emailing, and physical presence and rapport building. The absence in the virtual classroom of body language resulted in new ways of interacting and suggested a shift in teaching practice from controlling to engaging students.

A study of activity theory-based contradictions in distance education in Australian high schools sought to identify whether students were taking advantage of technology for their program-based communication, and whether they were learning through collaboration with peers (Fåhræus, 2004). The researcher's findings pointed to six contradictions within the activity system that made that outcome difficult but also pointed to the potential for expansive learning activities. For the purposes of the current study, the most applicable finding was that there was little collaboration between students because collaboration was not part of students' desired outcomes, which was to manage studies in order to pass an exam. The researcher noted that, with the introduction of Internet-based technologies to Australian stations (the contexts in which most students in the study were living) and the shift away from radio communication, the division of labor might shift, and students might find it less cumbersome to learn from one another or teachers might change their approaches to facilitate more collaboration (Fåhræus, 2004). This finding points to the contradiction between outcomes of different elements of an activity system but also nicely illustrates the manner in which activity systems work—a "tweak" to one element forces "tweaks" throughout the system.

A study conducted in a special education secondary-level classroom in Spain sought, through activity theory, to interpret the transformation that took place when commercial video games were used as an educational resource (Méndez & Lacasa, 2015). The researchers chose to use activity theory as their theoretical lens in part due to their acknowledgement that when a new instrument coexists with traditional practices, "the unit of analysis is defined by the contrast between two systems (entertainment vs. formal) that partially share the same object" (p. 278). In this particular study, the new instrument was the commercial video game and it contrasted heavily with the traditional practices of the special education classroom. The tensions that arose in the study were centered around different interpretations of stakeholders (community) of the purpose of using video games in the classroom, the change of the role of the teacher in the classroom, and the differing goals of students and teachers (Méndez & Lacasa, 2015).

A hybrid learning program in Japan which elementary school students attended periodically was the subject of an earlier activity-theory-based study (Yamazumi, 2008). The program was designed to address a growing problem in Japan—the disconnect between school learning and the development of life skills. The hybrid program imparted real world skills like cooking but in a comfortable and understandable classroom setting. Connecting the familiar learning context of the classroom with unfamiliar real-world skills provided an ideal situation in which the activity-theory concept of boundaries and tensions could be explored through a familiar object. The author concluded that new forms of expansive learning are needed but that "crucial contradictions" may be the key since such tensions energize efforts to transform systems (Yamazumi, 2008).

Activity theory was also used as the lens through which a district's laptop learning program was examined (Anthony, 2012). The longitudinal study sought to examine, by focusing on the district's teachers, changes that took place over time to lead to improved technology implementation (considered "the dynamic system of activity" in the study). Anthony (2012) found contradictions in the activity system between the district's technology planning system and the teachers' systems of technology integration. Because of these contradictions, integration was initially impeded, suggesting that technology integration is not a simple matter of professional development and device adoption—effective technology leadership is also essential, must extend beyond efforts to influence individuals, and should continuously assess the fit between elements within an activity system.

Finally, two previous studies have examined one-to-one initiative outcomes in relation to activity theory. Larkin (2011) used activity theory to analyze one-to-one initiatives implemented at the elementary and middle school levels with different student-to-device ratios (1:1, 1:2, and 1:1½). Using the theory to guide the analysis, Larkin concluded that, at the elementary level, one-to-two computing was more effective than one-to-one computing in terms of student engagement and learning, and students sharing netbooks developed greater collaboration. Holen, Hung, and Gourneau (2017) also examined high school one-to-one initiatives through the activity theory lens, using the theory as a conceptual framework supporting a mixed methods examination of a new initiative's success. The researchers' examination determined the interrelated factors that reflected how and why the initiative was successful with a focus in part on the 21st century skill set.

The previous studies have been highlighted in the literature review in order to detail recent school-based, technology-focused research that has employed activity theory as a theoretical lens. Although not a predictive theory, activity theory has proven successful as an exploratory guide to phenomena associated with education, allowing a nuanced understanding of how elements within a system interact to uncover tensions. This exploratory quality, as well as recent, successful studies examining one-to-one initiatives through the activity theory lens, makes it a highly appropriate tool to help guide this study.

One-to-One Initiatives

At the 1984 National Association of School Psychologists' Conference, Seymour Papert declared, "The computer is going to be a catalyst of very deep and radical change in the educational system" (p. 1). And yet, as noted by Larry Cuban in 2012, despite radical changes in communication and technology at all levels of society, the fundamentals of schooling have remained largely unchanged. While there are far more electronic devices in the hands of students and teachers, "how teachers teach and students learn have remained remarkably stable over the decades" (para. 7). As Cuban further noted, while claims about the power of electronic devices to "revolutionize" schooling are "a dime a dozen", those forwarding these claims have not considered the possibility that teachers are using the devices to teach as they have always taught (para. 4).

The predominance of recent empirical studies that focus on one-to-one initiatives are geared toward examining the use of the devices from the perspective of academic achievement (Abell Foundation, 2008; Carr, 2012; Grimes & Warschauer, 2008; Lowther et al., 2012; Zheng, Warschauer, Lin, & Chang, 2016). However, the findings from those studies are inconsistent, and researchers who have carried out achievement-focused studies have also advocated for an examination of student gains from a non-achievement-based perspective (Collier, 2008; Lowther et al., 2012; Mast Ryan, 2013; Zheng et al., 2016). More recent studies have also sought to better understand one-to-one initiatives in relation to 21st century skills.

Large-scale federal research studies on computer-based academic improvement programs and an extensive literature review found no evidence of improved reading achievement through the use of CAI programs (Allington, 2014; Slavin et al., 2009). In addition, studies have found inconsistent achievement patterns by year (Crook, Sharma, & Wilson, 2015) or gender (Dunleavy & Heinecke, 2007). A handful of peripheral findings suggested modest increases in general student achievement (Bebell & Kay, 2010; Bebell & O'Dwyer, 2010; Hayes & Greaves, 2013) in science, math, and reading (Dunleavy & Heinecke, 2007; Oliver & Corn, 2008; Rosen

& Beck-Hill, 2012) that might be attributed to one-to-one initiatives. However, two recent meta-analyses have suggested the potential of laptops in one-to-one initiatives to contribute to students' overall academic growth (Zheng et al., 2016).

Zheng *et al*. found 96 studies of one-to-one initiatives in grades 4-8 that met their criteria for a literature review and 10 that met their criteria for a meta-analysis. Zheng *et al*. reported moderate effect sizes of one-to-one initiatives in science and writing achievement (+0.25 and +0.20, respectively), while the effect sizes for English, math, and reading were smaller (+0.15, +0.17, and +0.12, respectively). In addition to these findings, Zheng *et al.* (2016) noted that one-to-one initiatives held potential for the development of 21st century skills, including communication due to their common use in writing tasks, collaboration due to their facilitation of parent-teacher-student relationships, and abilities in information and communication. This meta-analysis suggests that academic achievement in one-to-one initiatives can be statistically supported.

While there is now statistical evidence that one-to-one initiatives lead to gains in students' academic achievement, researchers are suggesting that laptop use may be able to contribute to moving students beyond achievement focused on academics toward a measurement of achievement that is based on the development of 21st century skills (Abell Foundation, 2008; Lowther et al., 2012; Prettyman, Ward, Jauk, & Awad, 2012). Gains that have been noted consistently are related to 21st century skills, defined for students as collaboration, communication, creativity, critical thinking, and career and life skills, and supported by teachers through curriculum and instruction, standards and assessment, professional development, and the facilitation of a supportive learning environment (Battelle for Kids, 2019a).

In light of the theoretical lens, activity theory, this section of the literature review examines one-to-one initiatives and 21st century skills through the tensions generated within schools when proceedings are viewed as an activity unit. Although an activity system cannot be broken into separate components, an attempt has been made to recognize tensions that potentially lead to 21st century skill outcomes in one-to-one initiative-related literature. In particular, the literature has been analyzed according to subject-tool-target, subject-tool-division of labor interactions, and tool-target-community interactions and their effect on 21st century skill development outcomes. In this particular cross-section of the laptop-initiative-focused literature, improvements in collaboration and communication were most often noted as a result of the initiatives.

Subject-tool-target interactions. When examined through the lens of activity theory, the interaction that emerges between the subject (teachers and students), tool (the devices in a one-to-one initiative), and target (integration of ICT into a school's educational activities) affects 21st century skills development. Although not the direct subject of study in examinations of one-to-one initiative outcomes, in many empirical studies, 21st century skills are addressed in the findings.

Communication. In many studies, the subject-tool-target discussion focuses on changes that occur in an educational institution due to new ways that teachers and students begin to communicate when one-to-one devices are introduced. Based on an extensive literature review focused on shifting dynamics and relationships in one-to-one device schools, Spires and colleagues (2012) suggested a reframing of the discussion of one-to-one initiative evaluations to focus at a more systemic level. When examined at a school level, as teacher and student relations begin to shift in one-to-one environments, it appears that overall communication tends to increase for students and teachers (Spires et al., 2012).

In support of this finding, in a mixed method research project carried out in an affluent district, students also noted this shift in communication in the school's culture, attributing the change to the availability of computers to communicate with teachers and one another in educational pursuits (Lei & Zhao, 2008). A larger study involving content analysis of 362 K-12 students' blog postings made over two years found that students recognized multiple benefits of a one-to-one initiative program, including better communication through writing (Zheng, Arada, Niiya, & Warschauer, 2014). The findings of these studies suggest that the subject-tool-target interaction is one that, through the natural tensions it causes, results in new ways of communicating between parties that in the past may not have involved themselves in communication. The use of laptops in a one-to-one initiative (tool) by students and teachers (subjects) in support of integrating ICT into educational activities may lead to the development of 21st century skills.

Collaboration. Students also have indicated improved collaborative abilities through one-to-one initiatives, although as noted earlier, an activity theory study forwarded conflicting findings. Researchers using a mixed method approach examined a one-to-one initiative within a private middle school and found that students' use of technology changed to encompass greater frequency of new modes of student collaboration, including sharing notes and co-editing wikis (Oliver & Corn, 2008). In a qualitative study in which middle school-level science-technology-engineering-math (STEM) students in a one-to-one environment were interviewed about perceptions of themselves as learners, they described themselves as good, self-directed communicators and able collaborators (Prettyman et al., 2012). The researchers argued that because of the school's teachers and the one-to-one environment, students were increasingly seeing themselves as creators of knowledge engaged with one another in that creation.

In a qualitative study in which English as a second language (ESL) classroom data were interpreted through grounded theory, researchers found that teachers used the devices to support a contextualized, collaborative, non-threatening environment (Turgut, 2012). The notion of "digital natives" and "digital immigrants", which asserts that immersive and interactive media has caused young people's brains to become "wired" differently, would suggest that the devices in Turgut's study might have been used effectively only by younger teachers (Prensky, 2001; 2006). Although Turgut did not reveal teachers' ages in the mentioned study, a contemporary article addressed the question of age and teachers' acceptance of technology, suggesting that a teacher's mindset, professional strength, and perceptions of workplace respect and support were better indicators than age of whether an individual might commit to the change process required for one-to-one initiatives (Tusch, 2012).

Creativity. Creativity and its development through one-to-one initiatives or any digital avenue is an area that has received little empirical attention. Studies associated with 21st century skills and one-to-one initiatives often have addressed creativity as a minor finding as compared to those that align more strongly (e.g. collaboration and communication) with measurable academic outcomes. However, the creativity-based outcomes of empirical studies can still be conceptualized in terms of subject-tool-target interactions.

In a qualitatively-based investigation, observations, extant data, and document analysis were used to investigate how educators in Virginia with exceptional access to 21st century tools engaged students in class work (Staib, 2011). Specifically, the study sought to determine how those 21st century tools (including laptop computers) affected teachers' abilities to facilitate a student- versus teacher-centered classroom and students' abilities to problem solve, work creatively, collaborate, and innovate. The results of the study revealed that, although students were highly engaged with technology, the teachers were extremely directive in students' use of those tools, resulting in a learning environment that the researcher described as technical in nature (Staib, 2011). This finding suggests that a failure to address and embrace the activity theory tension of subject (students/teachers)-tool (computer use)-target (student-centered classroom) also resulted in a failure of students to develop 21st century skills in this school system's program that was, in name, devoted to the development of 21st century skills.

A more recent concurrent mixed methods study which employed task content analysis sought to examine and describe classroom academic tasks middle school teachers were using to integrate in a one-to-one initiative while focused on satisfying CCSS (Hodgson, 2017). The researcher found that technology was used more than half the time (51.22%) to augment previously existing tools. All tasks using one-to-one technology which were addressed through task content analysis contained at least one element of the 4Cs of 21st century education, with critical thinking noted most frequently (90.24%) followed by creativity (56.1%) (Hodgson, 2017). The activity theory tension that resulted from the subject (teacher/student)-tool (ubiquitous computing initiative)-target interaction (CCSS) suggests 21st century skills outcomes.

When one-to-one-facilitated collaboration is examined through the subject-tool-target interaction, it becomes evident that the nature of the tool—the digital device—to engender connections between the subjects—the teachers and students—may contribute to collaboration and, therefore, 21st century skill development. Furthermore, communication is a natural result of collaborative interactions, unveiling the tension that is fundamental to the different parties that make up an activity system.

Subject-tool-division of labor interactions. When examined through the lens of activity theory, interactions that emerge between the subject (teachers and students), tool (the devices in a one-to-one initiative), and the division of labor (relationships between community members and task assignment) affect 21st century skill development. As with subject-tool-target interactions, this phenomenon has not been the primary area of investigation in empirical studies on one-to-one computing initiatives. However, the subject-tool-division of labor tension is essential in order for students to experience 21st century skill development.

Digital literacy*.* The subject-tool-division of labor discussion focuses on changes that occur in an educational institution due to new ways that teachers and students begin to divide labor, negotiate power hierarchies, and divide classroom tasks when one-to-one devices are introduced. In particular, as teachers guide students in one-to-one initiative classrooms, students become increasingly digital-literate experts. However, this increasing digital literacy shifts the division of labor away from traditional notions of an appropriate balance of classroom power, where the teacher is the holder of content knowledge and the student is the receiver.

This increase in digital literacy was seen to shift the division of labor as early as 2010, when Inan, Lowther, Ross, and Strahl sought to determine students' and teachers' patterns of classroom computer use. The researchers observed technology-integrated lessons in 143 classrooms in 39 middle schools in Tennessee that had received federal funds from the Technology Literacy Challenge Fund (Inan et al., 2010). In the course of the study, the authors noted that classroom teachers in technology-integrated lessons were more often acting as facilitators and coaches (90.1%) than delivering content through direct instruction (72.7%). Students were observed using technology as a learning tool (85.3%) rather than for instructional delivery (55.2%), perhaps due to the availability of the Internet and their frequent use of Internet browsers while looking online for information. It is important to note that teachers who used technology most frequently and effectively to facilitate this shift in the division of labor were those who were pedagogically ready to do so and held beliefs that aligned with such a shift (Inan et al., 2010). However, variables such as age and previous experience with computers and technology were not considered in the study and could have affected use patterns.

The same four researchers carried out a similar study in 2012 in Michigan to assess whether one-to-one initiatives adopted under the federal Freedom to Learn (FTL) grant bridged the way to developing 21st century skills (Lowther et al., 2012). In the 2012 mixed methods study, 380 FTL teachers and 5,770 students from FTL schools completed online surveys, and the researchers followed with classroom observations, student performance assessments, and school-developed technology benchmarks. Unannounced visits to FTL classrooms revealed that teachers were implementing more student-driven, ICT-reliant approaches like independent inquiry and project-based learning, but the overall degree and scope of the one-to-one initiative's impact was moderate (Lowther et al., 2012). The findings of this study suggest that tensions in the division of labor take place in one-to-one initiative classrooms and encourage digital literacy.

An earlier study sought to determine students' abilities to manage the information they were accessing online. According to the study, which involved the Educational Testing Service's (ETS) information literacy scores for 3,000 college students and 800 high-school students', one shortcoming of many high school students is an inability to reliably retrieve, analyze, and communicate information available online (Foster, 2006). A collaborative effort between a librarian and classroom teacher which required students to solve complex, authentic problems and apply research skills was suggested to remedy this inability and introduce students to a 21st century skill set—online research—perceived as necessary to a successful future (O'Sullivan &

Dallas, 2010). Online information management is a small segment of the 21st century skill set; indeed, more studies from the end of the first decade of the 21st century focus on communication, critical thinking, and problem solving.

Smaller-scale studies have also yielded results that suggest that the subject-tool-division of labor tension yields gains in 21st century skills. A qualitative study utilized focus groups and participant interviews among 24 preservice teacher candidates for data collection. The researchers aimed to describe video games' influence on the participants' views of the role of teacher as facilitator of instruction. In addition, the study contributed a greater understanding of desirable skills taught through digital technologies, and teacher candidates cited a slew of 21st century skills that were supported through digital game play, including technology proficiency (Sardone & Devlin-Scherer, 2009). Equally important for the current study, however, was the researchers' finding that video games affected the beginning of a paradigm shift for teachers in which candidates began to conceptualize teachers as facilitators of learning rather than directors of learning.

An earlier qualitative study involved three teachers during their first semester's use of laptop computers, with the researchers noting the paradigm shift that resulted during the transition to digital classrooms (Burns & Polman, 2006). The researchers discussed a reversal of teaching roles, with students outpacing teachers in their development of digital literacies, knowledge of computers, and what might be done with them. This section of the literature reveals that the subject-tool-division of labor tension that arises in one-to-one initiative environments may be essential if students are to become digitally literate.

Creativity. Although the results of qualitative research cannot be generalized, the findings of a multiple case study analysis carried out in 2013 reveals subject-tool-division of labor tensions. The study examined three middle school teachers' experiences, actions, and interactions that supported or inhibited technology integration during a one-to-one initiative (Jones, 2013). The researcher also gained teachers' perspectives on the challenges and successes they faced as classroom management and pedagogical practices changed with the infusion of ubiquitous computing in their classroom. All three teachers reported that they felt more creative in the design of curriculum and delivery of instruction and perceived that students were more motivated to apply knowledge creatively with the introduction of the ubiquitous computing initiative (Jones, 2013). In addition, the teachers perceived that students became less dependent upon them for answers and utilized technology, peer interaction, and grouping to solve problems.

To highlight students' voices in the discussion of creativity in one-to-one initiatives, a narrative account published by ISTE sheds some light on students' perceptions of learning through a one-to-one initiative (Miller, 2011). The featured students presented in front of the Iowa state legislature, stating that they felt that their education was changing through creating, connecting, and collaborating locally and globally through their laptops, describing using their laptops not just to interact and exchange ideas, but also to research independently, adapt to new situations and conditions, take ownership over their own learning, and create content independent of teacher input (Miller, 2011). This subject-tool-division of labor tension in these two articles suggests increases in creativity and innovation as teachers changed their approaches to teaching when involved in ubiquitous computing initiatives.

Tool-community-target interactions. When examined through the lens of activity theory, the interaction that emerges between the tool (the devices in a one-to-one initiative), community (the stakeholders in an initiative), and the target (the integration of ICT into classrooms) affects 21st century development. As laptops became more ubiquitous in schools in the mid-2000s, researchers began to consider their impact on stakeholders (community) beyond those encompassed by the subject realm of activity theory (i.e., students and teachers).

One early one-to-one laptop initiative instituted in 1999 provided laptop computers for 247 students and 24 teachers who were grouped into ninth grade learning clusters at three schools (Murphy, King, & Brown, 2007). The mixed method study of the initiative consisted of a pre-/post-survey, post-observation interview questions, and interview data, and sought to evaluate a laptop initiative's impact on a district's students, teachers, and parents through indicated knowledge, attitudes, and behaviors. Significant differences were noted between the different schools in the district as well as between the different stakeholders' feelings of self-efficacy, knowledge and attitudes, with the students at one school in the study noting significantly lower knowledge and attitudes related to classroom laptop use. A number of factors limited the generalizability of this study, including the short time between the administration of the pre- and post-survey and the small sample size of the parent group (Murphy et al., 2007). However, two of the study's findings—that the adoption of a one-to-one initiative must be related to a systemic change throughout a school's community and that funding and community support must be ongoing—have implications in light of activity theory. The study suggests that triangulated interactions between the tool, community, and target are essential to the success of one-to-one initiatives and the development of skills for the future.

A contemporary case study of three youths also noted the essential role of community in school technology initiatives (Barron, 2006). The researcher noted that the development of sophisticated competencies (soft skills) did not depend solely on a school environment—communities, peers, parents, and distributed resources (including books, tutorials, and online groups) all were found to be important impactors of learning outcomes. Technology, Barron stated, could make school boundaries more permeable, establishing that a very clear connection between the tool-target-community tension that may be essential to generating 21st century skill development in students.

A large-scale study carried out by the Texas Center for Educational Research (2008) sought to establish reasons that some schools involved in the Texas Technology Immersion Pilot had higher rates of technology immersion than others involved in the program. An implementation index was created to identify four schools with the highest implementation indices and four with the lowest implementation indices. Teachers' index scores were also used to identify those with indices in the highest quartile and those in the lowest quartile. By comparing these scores, the researchers determined that successful implementation of the technology pilot depended not on the characteristics of schools but upon the organizational conditions and the actions of individuals within the schools (Texas Center for Educational Research, 2008). The community within and around schools with higher rates of technology immersion (including the principals, parents, and support staff) displayed behaviors associated with support of teachers, expectations of effective technology use, encouragement, and positive and supportive attitudes. The findings of the importance of a systemic tool-target-community interaction contributed to the perceived success with technology implementation and, ultimately, students' perceptions of being prepared with 21st century skills for the future (Texas Center for Educational Research, 2008).

A more recent analysis sought to elucidate the six ways that schools that are successful with one-to-one initiatives differ from those that are not successful. Based on a literature review of research associated with one-to-one initiatives, the authors categorized questions, concerns, and issues related to classroom-based technology changes (Weston & Bain, 2010). Specifically, the authors found that the community's beliefs about technology were fundamental to a school's success as were clearly elucidated technology-related expectations for teachers and students. Of the six questions that Weston and Bain deemed necessary for schools to answer before adopting technology, four involved considerations of the community (What does the community believe about teaching and learning? Have the community's beliefs been assessed? Does the design of the program generate ongoing feedback from all stakeholders? Does the community have a shared conceptual framework for practice that is school-wide and requires ubiquitous use of technology?). The authors suggestions align neatly with the tension that, according to activity theory, is necessary to facilitate movement toward the outcome in the present study—the development of 21st century skills in high school students.

An article examining the Maker Movement, in which students were not just asked to use their laptops but to leverage them as a creative assistance device rather than the main vehicle for learning neatly wraps up this section of the literature review. Stager's (2015) article suggested the limitation of laptop initiatives to stimulate creativity, noting that laptop initiative schools must aim to "elevate the agency of learners beyond the desires of administrators or school-based management" (p. 28). In light of the current study, Stager's suggestion holds great import, making clear the notion that creativity, academic achievement, or any 21st century skill is not automatically conveyed in a laptop initiative but comes with changes that p result from such an initiative.

The roles of stakeholders (community), teachers and students (subjects), tools (laptops in one-to-one initiatives), new paradigms in envisioning each party's role (division of labor), and device use in schools (target) in relation to the outcome have been explored in the previous subsection. In the next section of the literature review, the focus will be on a growing body of research which has focused on 21st century skills as an entity that is largely separate from technology.

21st Century Skills

Although often touted as a technology-focused movement when implemented at the school or district level, more recently it has been noted that a 21st century education must be tied to outcomes, necessitating a move away from the dominant discussion centered around a vision of 21st century skills-based classrooms imbued in digital technologies (Bellanca & Brandt, 2010). The direction that this reform should take, however, is unclear—
should the 21st century skills movement be one based first on an immediate overhaul of school policy? Or should the movement be a more piecemeal one in which technology is allowed to change the face of schooling and the reform follows (Finn & Horn, 2013)? At its core, this question may be more about methods that arise in one-to-one initiative classrooms and schools by which tensions are addressed.

Alan November made a powerful and definitive statement in 2010, explaining why he believed that classroom and school initiatives focused around 21st century skills were more important than the tools used to develop those competencies. As November noted,

> The opportunity before us is to redesign the culture of our schools to empower students….to work collaboratively with classmates and people around the world. Asking the right questions about the design of an empowering culture of teaching and learning is more important than bolting technology onto our industrial model of education. (pp. 282-283)

Perhaps due to this clarion call for the reorganization of schools and redirection of learning, a number of subsequent empirical studies focused on ways of facilitating student learning at the high school level without the aid of digital technologies.

In an exploration of how to retool schools to fit the model necessary to accomplish 21st century skills, four forces were suggested that were redefining work and education in the early 2000s—a knowledge-based economy, digital lifestyles, the expanse of information due to ICT, and students' needs to learn while engaged in authentic activities and with other learners (Trilling & Fadel, 2009). While those forces are primarily technology-related, the technology tools are not the focus in the redefinition—the skills are the focus.

In reflection of this realization, the research-based discussion in the second decade of the 21st century began to diverge from a technology-focused one to a conversation increasingly focused upon 21st century skills being infused in the learning environment, the curriculum, daily instruction, professional development, and assessment (Bellanca & Brandt, 2010). As noted by Trilling and Fadel (2009), instruction needed to shift away from an exclusive focus on content and keeping one step ahead of students' knowledge of technology—teachers were encouraged to leverage the internet and classroom-based devices in creating meaningful learning experiences in order to develop students' abilities to solve real-world problems (Daggett, 2010). In essence, the increasing recognition of the importance of technology use extended beyond exclusive focus on the computer as the primary vehicle for learning. This shift in the literature brings this review to an examination of 21st century skills development through traditional pedagogies that do not necessarily incorporate digital technologies. The following section offers a review of empirical literature on 21st century skill development. As in the previous subsection, the literature is viewed through the lens of activity theory and the tensions necessary to elicit outcomes.

Subject-tool-target interactions. As described earlier, activity theory states that interactions, or tensions, are necessary to elicit a system's forward movement toward desired outcomes. As with the examination of one-to-one initiatives, the subject area is constituted of teachers and students and the outcome is 21st century skill development. However, the target has to do with curriculum and content, and the tool is any situation that generates authentic interaction between students in a manner that they must practice a 21st century skill set.

Among the earliest attempts to describe and measure students' general 21st century skill abilities was the Harvard River City Project (The River City Project, 2004–2007. Originally funded in part by the National Science Foundation and calling upon an early version of the P21 Framework, the first iteration of the project explicitly asked students (subject) to call upon 21st century skill and content knowledge (tool) in order to solve problems that occurred in the 19th century (target). The ultimate goal was for students, through simulations in multi-user virtual environments (MUVEs), to explore the virtual landscapes, develop and apply content knowledge, and collaboratively practice using, rather than simply experiencing 21st century skills (The River City Project, 2004–2007). The preliminary findings of Harvard-based research on the efficacy of MUVEs in sixth grade students in a Los Angeles laboratory school found that participants' communication skills increased as did engagement (Galas & Ketelhut, 2006).

The River City Project studies are among the earliest studies to contribute to an understanding of how students might develop 21st century skills in relation to interactive computer-based technologies. Interestingly, the researchers found that patterns of student involvement in learning through technology may reflect their general patterns of involvement in school-based, face-to-face contexts, especially in the areas of communication and collaboration (Dieterle, 2009; Galas & Ketelhut, 2006; Nelson, 2007). A study related to Harvard's River City Project found that girls sought out communication and collaboration functions in the form of embedded instruction when involved in MUVEs more often than boys (Nelson, 2007). However, findings from the research associated with the River City Project have been described as "equivocal", with students showing significant gains in content knowledge but decreases in measurements of collaboration, perhaps due to inconsistencies between the styles of assessment used to ascertain development and the desired outcomes of the River City Project (Dieterle, 2008; 2009). In addition, it is worth noting that the entire body of research on the River City Project has been published by individuals associated directly or indirectly with Harvard University.

A related study of 574 middle school students found that participants felt most connected in the virtual environment and believed in their competence in developing associated 21st century skill sets when they were comfortable with the media and tools being used, and the other people involved in the simulation (Dieterle, 2009). In a more recent mixed methods research study, 2,000 students' patterns of inquiry were examined while they engaged in the River City Project, tackling identical content and inquiry tasks in either paper-based or computer-based formats (Ketelhut, Nelson, Clarke, & Dede, 2010). Varied assessments demonstrated that those involved in the MUVEs were more likely to recognize skill development and were motivated by the virtual engagement.

Contemporary to the River City Project, University of California, Los Angeles's National Center for Research on Evaluation, Standards, and Student Testing (CRESST) published a report on the effect on 21st century skills of after school programs (Huang, Leon, Hodson, La Torre, Obregon, & Rivera, 2010). The researchers focused on fourth- and fifth-grade students (subject) attending an afterschool program in Los Angeles with non-technology activities (tool) designed to enhance self-efficacy and thereby also increase skills in learning process regulation (target). The authors of the CRESST report (2010) concluded that more efficient and effective learning process regulation results in more successful oral communication and collaboration skills. In addition, students with higher rates of attendance in the afterschool program demonstrated higher metacognitive abilities (Huang et al., 2010), suggesting that at least some 21st century skill sets can be taught in the absence of technology when there is a subject-tool-target interaction present in the learning environment.

Subject-tool-division of labor interactions. When attempting to answer the question: "What does a 21st century lesson look like?", several researchers have described necessary characteristics of lessons and teachers, as well as a suggested focus. In their description of a well-executed 21st century lesson, Duran, Yaussey, and Yaussey (2011) noted that the lesson must be meaningful and enjoyable to students (subject); contain elements that encourage student-centeredness marked by collaboration, engagement, and self-efficacy (division of labor), and provide an upbeat environment and academically challenging activities (tool). Technology, while incorporated into the lesson, was not noted to be a necessary element. In an ethnographic study of 21st century learning from Singapore, the researchers discussed the importance of a "broker" (subject) in an educational setting who helps a learner establish links between learning and informal contexts (tool) and assists not with direct instruction but with the transfer of learning strategies between the two (Hung, Lee, & Lim, 2012). The instructor in such a case is not there to teach (division of labor) as much as to facilitate connections, and technology is not an essential element.

In order to extend learning in new ways, transform pedagogy to a more student-centered approach, focus on student success, and prepare young people for a high-tech world, an exploratory case study found that problem-based inquiry (PBI) facilitated soft skills (tool), which helped students (subjects) deal competently with modern realities (Nariman, 2014). The author noted that digital technology in PBI should be regarded as a tool to extend learning in new ways (division of labor), and not as a supplement to traditional styles of instruction and learning.

Conclusion

In conclusion, as the 21st century skills discussion has unfolded into its second decade, an increasing number of voices have moved the conversation more firmly into the realm of education, and schools and school districts have placed into writing their intentions to impart and develop students' abilities to interact effectively with technology, communicate, collaborate, be creative, facilitate critical thinking skills development, and increase their dedication to job and life skills (Greenhill, 2010). Researchers have followed suit, focusing with greater frequency on 21st century skill development through any number of avenues, nearly quadrupling the number of studies that have focused on 21st century skills since the first ones appeared in the 1990s (Voogt & Pareja Roblin, 2012). This shift in research focus has resulted in the suggestion that, in order to successfully create a 21st century school, the entire culture and system of an institution would need to be overhauled. However, clarity is lacking in the exact direction of that movement. What is clear, though, is that shifts that may need to occur in one-to-one initiative schools in terms of instruction, learning, division of labor, and within communities may evoke tensions that result in 21st century skill development. It is possible that schools that have enlisted laptop computers in a drive to reformulate approaches to learning have not only improved academic outcomes but have also incidentally engendered 21st century skill development in the form of increased practice of digital literacy, creativity/innovation, collaboration, and communication.

This literature review has shown that the largest number of stakeholders in any school—the students—have been given only a limited voice in the technologization of education.

Students' perspectives have gone largely unnoticed in most empirical research, which has tended to focus on teachers and administrators rather than those who are doing the learning (Stager, 2015). In consideration of this realization, chapter three proposes an exploratory-sequential mixed methods research approach that includes the voices of students and teachers both. In addition, because no validated measure of 21st century skill development currently exists, the proposed methodology would explore the relationship between one-to-one initiatives and perceived 21st century skill development in these parties and address the development of an instrument to measure 21st century skill development.

CHAPTER THREE

METHODOLOGY

Since the final years of the 20th century, so called "21st century skill sets" have been identified as necessary for future workplaces (Levy & Murnane, 2007; Pink, 2005), and computer technologies have been linked to 21st century skill development (Kouzes & Posner, 1995; O'Toole & Lawler, 2006). As a result of this supposition and for a number of other reasons explained in chapter two, one-to-one initiatives are increasingly common in America's public high schools, with a 2015 report stating that one-to-one devices were available for more than half of the K-12 student and teachers in the US (Molnar, 2015). Naturally, as technocentric initiatives have grown increasingly common, efforts to understand them empirically have also become more frequent. Research on one-to-one initiatives has shown that participating students make significant academic gains; however, that same research suggests that students may be developing skills in communication, collaboration, creativity, critical thinking, content mastery, and digital literacy, or 21st century skills (Abell Foundation, 2008; Baines, 2015; James-Burdumy et al., 2009; Slavin, Lake, Davis, & Madden, 2009; Zheng, Warschauer, Lin, & Chang, 2016). The mixed methods study aimed to examine the perceptions of students and teachers involved in one-to-one initiatives around 21st century skill development. This understanding informed the development of a validated, reliable instrument to benchmark 21st century skill development in high school students involved in one-to-one initiatives.

Methodology Overview

This study followed an exploratory sequential design in which the initial qualitative phase was followed by a second phase in which the findings informed scale development (Creswell, 2012; Morgan, 1998; Onwuegbuzie, Bustamante, & Nelson, 2010). This approach was ideal for a study such as this one because a phenomenon was investigated among a relatively small group and with scale items emerging from a thematic analysis of the qualitative data (Terrell, 2012). More specific to 21st century skill research, this exploratory approach to instrument design filled a gap in the literature as most models and frameworks of 21st century skills have been developed by non-educational institutions.

Creswell and Clark's (2007) recommendations for mixed methods instrument development informed the procedure outlined below, as did the work of Hinkin, Tracey, and Enz (1997); Hinkin & Tracey (1999); and Onwuegbuzie *et al*. (2010). The exploratory approach followed two phases—a qualitative phase followed by a quantitative phase (Table 2).

Table 2

Six Steps of Scale Creation Addressed by the Current Study

Step	Area addressed	Guiding questions	Procedure	Product
Phase One				
1	Qualitative data collection	Dimensions of 21st century skill development identified within a 1:1 high school activity system?	Interviews, classroom observations	Field notes Transcripts
2	Qualitative data analysis	Themes around perceptions of 21st century skill development in 1:1 high school activity systems?	Coding Theme development	Coded text Themes Dimensions of perceptions of 21st century skill development
3	Qualitative findings	21st century skill themes and dimensions described through steps 1 and 2? Themes addressing the intersection between 1:1 initiatives, 21st century skills, and activity theory?	Themes/dimensions described	Descriptions & proposed items for inclusion
Phase Two				
1	Validity/reliability review	Are the items conceptually consistent (content validity)? Clear? Appropriately worded for tone, length, cultural considerations? Do the items measure what they are supposed to?	Piloting with validity-imparting subject matter experts (n = 12); I-CVI; S-CVI/Ave; MK	Revised instrument with 17 items eliminated & 34 items included
2	Field test revised instrument/ Reliability review	Is the content adequate to measure the expressed domains? Which variables might 'go together'? Which items require pilot testing?	Sample size: 53 participants; ANOVA; Q-correlations; EFA	31-item instrument with variables adhering to 21st century skill domains
3	Overall results	How might items be classified (by which domains) on the final scale?	Summarize dimensions Present evidence for validity and reliability	Validated, reliable instrument ready for pilot testing

Note. I-CVI = item content validity index; S-CVI/Ave = scale content validity index average; MK = modified kappa; ANOVA = analysis of variance

Creswell and Clark (2007) represented these phases as QUAL→quan and suggested that such an approach results in a reliable, validated scale.

Onwuegbuzie and Combs (2011) recommended developing specific areas of awareness before entering into mixed methods research and emphasized five areas in particular which are essential to researcher awareness: rationale/purpose for conducting the mixed analysis, the number of data types collected and analyzed in the study, the time sequence for the mixed analysis, the priority of the analytical components, and the number of analytical phases. The purpose of mixing methods in the current study was to achieve scale development through sequential data collection and analysis. Two data types, therefore, were analyzed in the current study: qualitative in phase one with the analysis of the qualitative data driving item creation in phase two. By prioritizing the qualitative data collection and analysis, the study can be described as a qualitative-dominant mixed analysis and the researcher assumed a constructivist-poststructuralist-critical stance with respect to the mixed analysis process, conveying the belief that the inclusion of quantitative data and analysis will provide richer data and interpretations (Onwuegbuzie & Combs, 2011).

Table 3

Areas of Awareness to Develop Before a Mixed Methods Study

Area	**General Explanation**	**Application in Current Study**	**Explanation for Current study**
Rationale/purpose for conducting the mixed analysis	Study meets one of more rationales/purpose: • triangulation, • complementarity, • development, • initiation, or • expansion	Instrument development	Data collected sequentially. Findings from one analysis type informed data analyzed using another approach.
Number of data types that will be analyzed	Study involves analysis of one or both data types (i.e., quantitative data or qualitative data; or quantitative data and qualitative data)	The data corpus consisted of semi-structured interviews and classroom observations.	Data generated from phase one analysis (qualitative) converted to inform the scale development of phase two.
Time sequence of the mixed analysis	Design-based mixed analysis directly linked to the design, or Phase-based sequential analysis taking place in one or more phases	Sequential, phase based	Qualitative analysis component conducted first; analysis informed subsequent scale.
Priority of analytical components	The priority or emphasis given to each component (qualitative and quantitative).	Qualitative analysis component received priority, informing the quantitative phase (QUAL→ quan)	The analyst assumed a constructivist-poststructuralist-critical stance.
Number of analytical phases	Seven phases identified: 1. data reduction 2. data display 3. data transformation 4. data correlation 5. data consolidation 6. data comparison 7. data integration	Stages one through three undertaken	**Stage 1**: Reduction of data dimensionality **Stage 2:** Visual description of data **Stage 3**: Data transformation (survey)

Note. Adapted from "Data Analysis in Mixed Research: A Primer," by A. J. Onwuegbuzie & J. P. Combs, 2011, International Journal of Education, 3, 1, 13.

Finally, an awareness of the analytical phases guiding the study is essential. Onwuegbuzie and Teddlie (2003) recommended the analytical phases of data reduction, data display, data transformation, data correlation, data consolidation, data comparison, and data integration (Table 2). The researcher collected and analyzed data in phase one through a multiple case study and compared and contrasted themes between cases (Yin, 2009).

Research Objectives, Research Questions, and Study Alignment

The research questions that drove the study focused on the development of a validated and reliable instrument for measuring 21st century skills.

Research Question One: What outcomes are identified within an activity system in which one-to-one devices are the mediating artifact?

Research Question Two: What 21st century skill development is identified by students and teachers in an activity system in which one-to-one devices are the mediating artifact?

Research Questions Three: What items in a 21st century skill-measuring instrument represent the results of the qualitative phase of research?

Each question, the variables under analysis, the timeline for application, and the type of analysis employed are described narratively below.

Research Question One

Research question one is, "What outcomes are identified within an activity system in which one-to-one devices are the mediating artifact?" To answer research question one, student focus group interviews and one-on-one interviews with classroom teachers followed a semi-structured interview protocol (Appendix D & E). The researcher's intent in this approach was to elicit spontaneous descriptions (Krueger & Casey, 2001) from teachers and students involved in high school one-to-one initiatives. Each research question and objective aligned with the different elements of the purpose of the study, the variables under consideration, and the implemented analyses (Table 4) with the intent of eliciting spontaneous descriptions (Krueger & Casey, 2001).

Table 4

Alignment Within Study

Purpose	**Research Questions**	**FGQ**	**TQ**	**Variables**	**Instrument**	**Analysis**
Describe tensions within an activity system in which laptops are the mediating artifact	RQ 1: What outcomes are identified within an activity system in which one-to-one devices are the mediating artifact?	3 5 6 8 9 10	4 6 8 11	-Outcomes -Elements of an activity system -1:1 laptops	Student focus group and teacher interviews	Thematic analysis
Identify 21st century skill development in a 1:1 laptop program	RQ 2: What 21st century skill development is identified by students and teachers in an activity system in which one-to-one devices are the mediating artifact?	2 4 6 7 8	3 5 7 9 10	-21st century skills outcomes -Elements of an activity system -1:1 laptops	-Focus groups (Krueger & Casey, 2001) -Teacher interviews -Classroom observations	Thematic analysis
To identify items that are appropriate, valid, and reliable for inclusion on a 21st century scale	RQ 3: What items in a 21st century skill-measuring instrument represent the results of the qualitative phase of research?	1 Align-ment sought between all data	2 Align-ment sought between all data	-21st century skills outcomes	Developed scale	I-CVI S-CVI/Ave MK ANOVA

Note. RQ = research question; FGQ = focus group question number aligning with this research question; TQ = teacher question aligning with this research question; I-CVI = content validity index; S-CVI/Ave = scale content validity index average; MK = modified kappa; ANOVA = analysis of variance

Research Question Two

Research question two is, “What 21st century skill development is identified by students and teachers in an activity system in which one-to-one devices are the mediating artifact?” The purpose of this qualitatively-focused question was to encourage participants to identify 21st century skill development in a one-to-one device program; classroom observations, focus group interviews, and one-on-one teacher interviews provided data for this question. The researcher followed a modified 21st century skills-focused classroom observation protocol (Appendix F) to lend focus and provide triangulation of data sources (Henrico 21st Century Teaching and Learning, n.d.; Moersch, 2013).

Research Question Three

Research question three is, “What items in a 21st century skill-measuring instrument represent the results of the qualitative phase of research?” The purpose of this research question was to determine whether the items in the developed scale adequately represented the results of the qualitative research. The researcher answered this question through an assessment of content validity and reliability. Quantitative analyses included calculating each item’s content validity index (I-CVI), and the scale content validity index average (S-CVI/Ave) for the scale in its entirety and the individual 21st century skill domains. A modified kappa (MK) coefficient reflected reliability and analysis of variance (ANOVA) was used to detect statistical differences between domains within each item.

Appropriateness of Study

A mixed methods research approach enlarged understanding of the 21st century skill and one-to-one device phenomena, added fullness to the study, and allowed for triangulation of findings within the data corpus (Onwuegbuzie & Leech, 2006). Because at the time of writing no scale existed to measure 21st century skill development in high school students, the researcher employed a mixed method research methodology. Data from observations, focus groups, and teacher interviews collected within each of the three participating schools increased the power of the inferences that might be drawn from the data (Kemper, Stringfield, & Teddlie, 2003) and aligned the study with activity theory. The mixing of data collection methods (Table 5) covered for the weaknesses inherent to the different data collection approaches and allowed a fuller picture of the phenomenon at hand to emerge (Blair, Czaja, & Blair, 2014). The study focused

Table 5

Balance of Data Sources

Data Source	Strength	Weakness
Observation	Not subject to reporting bias	Cannot measure mental states Subject to observer bias
Focus group interview	Can probe freely and deeply Reveals social dynamics	Poor population coverage
Survey	Measures mental states Inexpensive	Subject to reporting bias Excellent population coverage

Note. Adapted from “Designing surveys: A guide to decisions and procedures,” by J. Blair, R. F. Czaja, & E. A. Blair E. A., 2014, Thousand Oaks, CA: Sage.

on high schools with one-to-one initiatives with co-occurring 21st century skill statements.

One-to-One Devices

The current study focused on one-to-one initiatives in general rather than focusing on the use of one type of device (e.g. iPads, Chromebooks, Surface Pro). This decision was based on a study which found that no matter the type of device employed, when implementing a ubiquitous computing program, school districts would undergo similar experiences. In short, for the purpose of the current study, the type of device adopted was decided to be inconsequential when compared to the potential non-academic outcomes of the initiative (Deloatch, Hendron, Kim, & Tolliver, 2014).

Multiple Case Study vs. Ethnography

Carrying out an ethnography would have been ideal for a study such as this one due to its ability to “examine teaching and learning through the lenses of social life and the perspectives of teachers and students—notably to embrace polyphonia” (Tobin, 2010, p. 406). However, ethnography’s requirement, that the researcher embed deeply within one context and explore that system thoroughly, would have disallowed the broader understanding that a multiple case study imparted. Practically speaking, completing three ethnographies would have been overwhelming for a novice researcher and the resources necessary for such extended research were unavailable.

Including Different Types of Schools

Ideally, each of the one-to-one initiative high schools in the study would have represented a state with a different level of Common Core State Standards (CCSS) acceptance. The rationale behind such a move was that different levels of adherence would potentially impact the level of 21st century skill acceptance and willingness or ability to embrace in-school technology use. In the end, the schools participating in the qualitative portion of the study represented not only different levels of CCSS acceptance (i.e. non-CCSS accepting and partial CCSS accepting) but also very different socioeconomic situations, geographical locations, and institutional cultures.

Methods

Because of the mixed methods design and the aim of creating a validated and reliable scale to measure 21st century skill development, the researcher carried out the study in two phases with different individuals involved in each phase. Phase one was exploratory in nature with a data corpus composed of focus group interviews with students, an observation protocol (Appendix F) and accompanying notes, and teacher interviews. Phase two drew from a pool of subject matter experts (SMEs) and undergraduate education majors.

Phase One Recruitment

Phase one required recruitment of three high schools with students to participate in focus groups, and teachers to be observed and interviewed.

School recruitment. The researcher initially attempted to recruit participating schools in the spring of 2017 through the International Society for Technology in Education (ISTE) and the

Society for Information Technology and Teacher Education (SITE). Through the call for participants, both teachers and administrators were offered the option to nominate their schools for participation in the study. However, the respondents to this call for participants did not fit required characteristics (i.e. one-to-one initiative in place school wide for at least one year with a 21st century skills-focus listed in associated literature as an aim of the school or district).

In the summer of 2017, the researcher approached 19 high schools in states with different levels of CCSS acceptance to participate in the qualitative portion of the study after identifying one-to-one initiative high schools through Google searches using individual state names and the terms “one-to-one initiative,” “iPad initiative,” “Chromebook initiative,” “high school,” “technology initiative,” and “user agreement.” Using the results of the search, the researcher created a spreadsheet for each state which included contact information and details about the schools’ initiatives gleaned from online news sources, school and district websites, and press releases. The researcher sent emails to individuals identified as spearheading the initiatives and then followed up with phone calls.

Of the 19 schools approached, seven superintendents or heads of school returned phone calls and indicated an interest in participation. Of those seven administrators, two were able to secure permission for student interviews in July of 2017. The third school required a research application, and a research board approved the study in September of 2017.

Teacher and student recruitment. In the fall and winter of 2017, the researcher made initial visits to the three participating schools to discuss student and teacher recruitment. Within each school, teachers and administrators identified students who would be willing communicators and invited those students to participate in focus groups. Administrators advised groupings among students who returned parental consent forms (Appendix C), with between two and eight students in each group. Students were advised that they would also be asked to sign assent forms (Appendix B) before taking part in the focus groups. School administrators also identified teachers who might be willing to be observed and participate in one-on-one interviews to discuss their involvement in one-to-one initiatives. Administrators advised teachers that they would be required to given written consent (Appendix A) and verbal consent to participate in the study.

Phase One Interview and Observation Protocol Development

The interview process began with the development of interview and observation protocols and concluded with seven one-on-one teacher interviews and seven student focus group interviews.

Interview protocol development. The researcher created the focus group and teacher interview protocols in the spring of 2017 based on 21st century skills literature (Battelle for Kids, 2019a; Voogt & Pareja Roblin, 2012); activity theory (Cole & Engeström, 1993); and the writings of Soland, Hamilton, and Stecher (2013) and Blair *et al.* (2014). The researcher then presented the two protocols (each with 15 potential questions) to a group of experts in classroom technology use, literacy, 21st century skill development, and educational policy for feedback. From their feedback, the researcher eliminated five questions on each protocol and revised three questions on each to arrive at ten focus group questions and ten teacher interview questions. The researcher then received feedback from her two teenage children on the wording and clarity of each student focus group item. The resultant protocols appear in Appendix D and E.

Observation protocol development. The researcher developed the observation protocol based on Henrico Public School District's protocol and the H.E.A.T. Protocol. (Henrico 21st Century Teaching and Learning, n.d.; Moersch, 2013). Each protocol focused on the domains of

21st century skill development and their relationship to classroom computer use, and classroom behaviors and practices, bringing attention to the teachers' and students' roles and the nature of the learning experience within the context of 21st century skills. Specific observation factors included the identification of instruction and/or practices that promote or deny instruction in communication, collaboration, and digital literacy; the purpose of the implementation of the 21st century skills observed; the content associated with the skill implementation, and the delivery mode of instruction (LoTi Organization, 2015).

Phase One: In-School Data Collection

In-school data collection occurred over 2–4 non-consecutive school days. On those days, school administrators provided the researcher with a space to conduct focus group and one-on-one teacher interviews and granted varying levels of access within the schools' grounds. In one school, the researcher was given free access to the entire school and encouraged to visit any classrooms at any time. In a second school, the researcher was allowed to walk through the grounds independently but was advised to visit only assigned classrooms. In the third school, the researcher's access was restricted to the administrative portions of the school, and the principal acted as an escort for teacher interviews and classroom observations.

Student focus groups. With the exception of one group which took nearly two hours over two separate school days, focus group interviews took between 25 and 45 minutes to complete. Meetings took place between February and April 2018 in school conference rooms, principals' offices, empty classrooms, or school libraries. Following the recommendations of Krueger and Casey (2001), focus groups consisted of between two and eight students sitting in a circle around a table to create a permissive environment, which has been noted as essential to an effective focus group session. The researcher recorded all focus group interviews with an

Olympus digital voice recorder (WS-853), and the VoiceRecorder app installed on the researcher's iPhone 5 acted as a back-up device in case of potential issues with the first device. The researcher placed both items in the center of the table and turned them on after receiving student assent (Appendix B) and explaining to students the reason for making the recordings.

Teacher interviews. Teacher interviews took between 20 and 45 minutes. The researcher met face-to-face with all participating teachers in empty classrooms, hallways, teacher workrooms, or in vacant administrative offices. With the exception of one interview, the researcher met with teachers immediately following classroom observations. For the exception, the teacher and researcher met without a previous observation due to scheduling conflicts related to testing and snow days. The same Olympus digital voice recorder (WS-853) and VoiceRecorder app captured the interviews. During the interviews, teachers and the researcher faced one another, sharing a tabletop in all but two situations. In one case, the teacher and researcher occupied separate desks in a classroom but faced one another. In the other exception, the teacher stood outside her classroom to monitor the hallway while the researcher sat at a student desk.

In-class observations. The researcher observed seven grade-9–12 classrooms, with one to three observations carried out in each school. The researcher carried out the observation protocol as an intramethod mixed observation, employing both qualitative and quantitative characteristics (Johnson & Turner, 2003). Each observation incorporated extensive field notes and a checklist-style protocol (Appendix F). The researcher followed an observer-as-participant role, spending a limited amount of time inside the group after informing teachers and students that they were being observed. In two classrooms, teachers encouraged the researcher to circulate around the classroom during instruction. Otherwise, the researcher conducted observations from a space behind students where device screens could easily be seen.

The researcher also made observations in each school's public spaces, including hallways, school grounds, cafeterias, libraries, and common areas. The researcher made sketches and, where permission was granted, took photos of physical features that might support 21st century skill development, including benches and seating where students might collaborate outside of classes and displays of student projects. Sketches of school layouts and observations of students moving between classes also contributed to an understanding of how the participating schools might be supporting 21st century skill development.

Phase One Data Analysis

As thematic coding has proven effective for scale development, the researcher used this approach to analyze the qualitative data (Creswell & Clark, 2007; Myers & Oetzel, 2003). Braun and Clarke (2006) conceptualized thematic analysis as "a method for identifying, analysing, and reporting patterns (themes) within data" (p. 6) and detailed a six-step process to accomplish this pattern identification. As the sixth step of Braun and Clarke's process is "producing the report" (i.e. generating chapter four), only steps one through five are described below.

Step one: Familiarization with the data. This step of data analysis involves creating a deep familiarity with the data achieved by reading through the data corpus carefully multiple times, all the while searching for meanings and patterns (Braun & Clarke, 2006). To achieve this deep familiarity, within 72 hours of conducting interviews, the researcher scored observation rubrics by consulting field notes. Additionally, the researcher listened to the interview recordings and then transcribed them using the Google Voice-to-Text function in Google Docs. Once each individual interview was complete, the researcher copied and pasted the transcription into a Microsoft Word document, and listened to the interview a third time to confirm accuracy of the language in the transcription. On the fourth listen, the researcher added punctuation marks to create a level two transcription, adding meaning and inflection with prescribed symbols (Du Bois, 1991). The researcher then added line numbers and read the data again, searching for meanings and patterns. With each reread, the researcher made notes and marked ideas for codes.

Step two: Generating initial codes. The researcher began at this stage to produce initial codes, organizing the data into meaningful groups within each 21st century skill theme. To generate initial codes, the researcher began by converting Word files to Rich Text Format (RTF) and then uploaded them to AntConc to reveal initial patterns in language within each of the 21st century skill domains. Content mastery also emerged as an observed phenomenon in all classes and as a response offered by both teachers and students when discussing 21st century skills during interviews; content mastery was added at this stage as an additional theme to consider during further analysis. To track codes, the researcher created a code book and also organized data with NVivo Software, Version 11 (QSR International, Melbourne, Australia); however, due to technical and licensing issues, NVivo became too cumbersome, and the researcher elected to use Microsoft Excel to complete the analyses.

Within Excel, the researcher created a sheet for each school using a pseudonym, and then created additional sheets for each teacher interview and student focus group. Finally, the researcher created one sheet for all of the teacher interviews, another sheet for all student interviews, and a third to tally notable frequencies. In total, the researcher created 18 sheets in one Excel file. In each Excel sheet (except the Frequencies sheet), the researcher created six columns labeled “transcript line number,” “site pseudonym,” “participant pseudonym,” “source number,” “code” (matched to the code book), and “specifics” which contained notes and context for the code. The researcher coded as many themes and patterns as possible, retaining contradictory codes and also keeping surrounding data as often as possible (Braun & Clarke, 2006).

Step three: Sorting codes into themes. After all transcripts and observations had been entered and data had been coded and collated, the Sort function in Excel assisted with examining data across cases and between cases to lead to the broad identification of themes and subthemes. It was in this step that the researcher began to sort the different codes into the 21st century themes while also identifying unanticipated themes.

To combine the codes into themes and subthemes within their 21st century skill areas, the researcher took two approaches: mind mapping and sorting codes into tables in Microsoft Word. Within Word, the researcher created tables in separate documents for each 21st century skill theme as well as the different themes that evolved during step two above. Subthemes headed the columns of tables, and the researcher populated the cells with codes that supported or explained each subtheme. At this stage, important individual themes and their characteristics and definitions became evident.

Step four: Refining themes. As noted by Braun and Clarke (2006), in this step themes collapse into one another, and expand, contract, and evolve. After categorizing step three information in Word document tables, the researcher was able to see collated extracts of data under each theme and subtheme and consider whether those extracts formed a coherent pattern. Searching for coherence also highlighted the fact that some themes were not actually independent themes at all but were parts of larger themes, so the researcher collated some data again. Additionally, some data originally categorized under one theme was too diverse in scope, necessitating the reconsideration and development of new themes.

By the end of this step, the researcher was able to begin to make notes on the story contained within each theme, developing nascent definitions of 21st century skills from the study participants' perspectives and beginning to understand their expectations of outcomes of one-to-one initiative high schools. In further support of these themes, the researcher read the entire data set again to determine whether the identified themes accurately reflected the meanings in the data set as a whole. The researcher coded data not previously coded in this step and also recoded some data as new themes emerged.

Step five: Defining themes. In this step, the researcher identified the "essence" captured by each theme, determining the "aspect of the data each theme captures" (Braun & Clarke, 2006, p. 23). To accomplish this end, the researcher printed the theme tables developed through previous steps and organized data into a coherent narrative, highlighting not only the content of the data extracts but also identifying. A novice researcher runs the risk of not knowing when themes are refined enough to stop qualitative analysis. With this hazard in mind, the researcher occasionally tested for doneness by attempting to describe each theme's scope and content. As noted by Braun and Clarke (2006), the researcher should be able to accomplish this task in a couple of sentences; inability to do so indicates the need for further refinement of that theme. The researcher finished this step by ascribing labels to each of the themes, arriving at 52 potential items to include in the 21st century skill-measuring instrument tested in the subsequent quantitative phase of the study.

Phase Two Recruitment and Data Collection

The data collected in the qualitative phase of the study resulted in proposed items for inclusion on a 21st century skills measuring instrument. Phase two required two rounds of data collection involving a total of 65 participants, with step one calling on a panel of experts (N = 12) to consider the importance of individual items within the proposed instrument. Step two called on university students (N = 53) to assess the adequacy of the instrument's content.

Step one: Content validity and reliability. For step one of quantitative data collection, the researcher sent an open call in October of 2018 for participants through professional social media networks, specifying that participating individuals had to have authored studies addressing educational technology, taught classes that include technological elements, or been involved in 21st century classrooms or programs. Individuals who responded favorably to the call received emails with the link to a Qualtrics-based survey containing the 57 proposed items. In total, 15 subject matter experts (SMEs) responded to the email-based link; 12 SMEs submitted a completed survey. The researcher discarded the three partially completed responses.

SMEs evaluated items for clarity and their favorability toward one-to-one initiatives and their possible relation to contributing to the development of perceptions of 21st century skills. The statements and rating structure followed Likert scale design procedures due to the benefits imparted in terms of time and labor (Edwards & Kenney, 1946). For each proposed item, the individuals assigned a numerical rating of favorability between 1 (weakest) and 10 (strongest) indicating the degree to which each item indicated perceptions of 21st century skill development. SMEs also assessed items for clarity, choosing 1 for clear and 2 for unclear. SMEs also had opportunities to make suggestions for improving the clarity of items.

Step two: Content adequacy. In December of 2018, the researcher approached 55 students from a university on the East Coast of the United States to pilot test the proposed instrument and indicate the instrument's adequacy in addressing the proposed 21st century skill domains. To participate in step two of data collection, the participants had to be involved in a teacher training program and have graduated high school within the previous five years. Of the 55 students approached, 53 gave written consent and agreed to pilot test the instrument. The researcher executed this round of data collection with a paper-based survey due to concerns around connectivity.

Participants assessed each item for the extent to which it adhered to the 21st century skills domains identified in phase one (i.e. communication, collaboration, critical thinking, creativity, content mastery, and digital literacy). The survey began with a definition of each 21st century skill and asked participants to indicate on a five-point Likert scale the extent to which they believed each item belonged within the identified domain, ranging from one (not at all consistent) to five (completely consistent). Three versions of the questionnaire were presented with items placed in different orders to control for response bias due to order effects (Hinkin et al., 1997).

Phase Two Data Analysis.

In this phase of analysis, the researcher strove to establish content validity, reliability, and adequacy.

Step one: Content validity and reliability. The researcher began the process of assessing content validity by converting Qualtrics data into a Microsoft Excel file and averaging SMEs' ratings to arrive at a mean numerical rating (MNR) for each item. The researcher then calculated I-CVI to determine SMEs' agreement around each item's validity. The I-CVI is a linear transformation of the number of experts within a panel who rate items as "essential" or strong and is an item statistic used to reflect retention or discarding individual items in survey creation (Gilbert & Prion, 2017). I-CVI was calculated as follows:

$$\text{I-CVI} = \frac{n_e - (N/2)}{N/2}$$

where n_e is the number of panel members indicating an item is essential and N is the total number of panel members (Lawshe, 1975). A recent revision of Lawshe's methods of calculation suggests critical I-CVI values for panel sizes. According to Ayre and Scally (2014), for a panel of 12 SMEs, the essential proportion of agreement is .833 with a critical exact value of .667. However, according to Lawshe (1975) and Gilbert and Prion (2017), any items perceived as strong items by more than half of panelists have some degree of content validity. The greater the number of panelists perceiving an item as essential, however, the greater the extent of that item's CVI. In the current study, the researcher considered an I-CVI of .833 or higher as ideal but accepted an I-CVI greater than .50 if the item had a corresponding mean of 7.1 or higher, unanimous statements of clarity, and an MK statistic of .61 or higher, which conveys statistical agreement.

While the I-CVI tells about individual items' content validity, the scale content validity index average (S-CVI/Ave) reflects of validity of the entire instrument and for individual domains within an instrument. The S-CVI/Ave is the mean of I-CVI values for items included on a scale (Polit, Beck, & Owen, 2007). Previous researchers have recommended that a S-CVI/Ave should exceed .70 (Tilden, Nelson, & May, 1990), but an S-CVI/Ave of .80 is preferred (Davis, 1992). Following these recommendations, in the current study the researcher considered a S-CVI/Ave of .70 as acceptable but one of .80 as ideal.

The researcher also calculated modified kappa (MK) coefficients for each item as a measurement of reliability (Cohen, 1960; Kraemer, 1979). The kappa coefficient accounts for chance agreement, or that the classification was made randomly between raters, with a MK of one indicating perfect agreement and zero indicating agreement entirely by chance (Vanbelle, 2016). MK coefficients, therefore, can be conceptualized on a scale of 0–1, as in Table 6 (Viera & Garrett, 2005).

Table 6

Kappa Coefficient Interpretations

Scale Score	Interpretation
0.01–0.20	Slight agreement
0.21–0.40	Fair agreement
0.41–0.60	Moderate agreement
0.61–0.80	Substantial agreement
0.81–0.99	Almost perfect agreement

The researcher calculated the MK coefficient as follows:

$$MK = \frac{P_o - P_e}{1 - P_e}$$

where P_o is the observed agreement, and P_e is the expected agreement. The calculation, therefore, is the difference between the agreement actually present (P_o) and the agreement expected by chance (P_e). This difference is then divided by the value of perfect agreement (1) less the value of the expected agreement (Viera & Garrett, 2005). The statistical approaches above led to item elimination, and the 34-item survey was ready for an evaluation of content adequacy.

Step two: Content adequacy. For determining content adequacy, the researcher began the process by downloading Qualtrics data into Microsoft Excel and restructured the dataset, transposing the items to a vertical orientation and stacking respondents' scaled responses to construct a 34 x 6 table of the average ratings for each of the six subscales provided by the SMEs for each item in the instrument. The researcher then used Excel to calculate the means and standard deviation across each item.

Due to Excel's limitations around data analysis, the researcher then transferred the data into Statistical Package for the Social Sciences (SPSS), Version 25 (IBM Corp., Armonk, New

York, USA), restructuring the dataset into a long format to run a Levene's test for violations of assumptions for the classical one-way analysis of variance (ANOVA). Levene's test uses an F-test to test the null hypothesis that the variance is equal across groups, and most items failed this test. A Brown-Forsythe ANOVA test was therefore run with significant results ($P \leq 0.05$) for all items but one, suggesting the adequacy of the proposed items to represent the 21st century skill domains. Likewise, the assumptions of the traditional Tukey post hoc analysis were violated. Therefore, the Games-Howell post hoc test was used to detect significant differences between perceptions within the six study domains. To be considered adequate for measuring a domain, the item's mean in one dimension had to be statistically significantly different from at least one other mean (Hinkin & Tracey, 1999).

The researcher then assessed correlations by creating an item-by-item Q-correlation matrix followed by exploratory factor analysis (EFA). EFA relies on the fulfillment of six assumptions: adequate sample size to carry out the proposed analyses, linearity of data, the absence of outliers, a lack of extreme multicollinearity, and a low percentage of missing data. The question of a number that constitutes an adequate sample size is unclear in the literature, although there is general consensus that a larger sample size yields more precise results in EFA (Beavers, Lounsbury, Richards, Huck, Skolits, & Esquivel, 2013). The current sample size was on the low end of subject-to-item adequacy, but strong loadings (.50 or above) under each factor suggest that the current sample size was acceptable. The data possessed acceptable linearity, with items correlating to varying ranges within each proposed domain. However, correlation matrices revealed correlations exceeding .30 for every item, providing enough evidence to indicate sufficient commonalities to justify comprising factors (Beavers et al., 2013). The use of a Likert scale limited outliers. Extreme collinearity was absent, and less than 1% of responses in the overall dataset were absent. EFA, therefore, was a realistic approach for determining whether the given variables correlated with one another.

The first step of carrying out EFA in the current study was to determine whether there was a significant difference between items in relation to the six domains of 21st century skills identified in the qualitative portion of the study. For determining this content adequacy, the researcher calculated the means and standard deviation across each item and then ran a Brown-Forsythe ANOVA test which yielded significant results ($P \leq 0.05$) for all items. A Games-Howell post hoc test revealed significant differences between specific perceptions within the six study domains. Because the mean in at least one dimension was statistically significantly different from at least one other mean for each item, the proposed survey items were determined to adequately and uniquely represent the 21st century skill domains, and all items were retained for the EFA. The descriptive statistics and items' corresponding *F*- and *P*-values can be seen in Appendix G. The researcher then assessed correlations by creating an item-by-item two-tailed Q-correlation matrix. The item-by-item Q-correlation revealed significant correlations ($P \leq 0.05$) for all items, satisfying one assumption of an EFA.

The researcher organized the analyses by domain, conducting each analysis under one of the six domains identified in the qualitative phase of the study (i.e., communication, collaboration, critical/expanded thinking, content mastery, creativity, and digital literacy). For each analysis, the researcher sought to determine the proportion of variance among the items within the domain, with the first factor extracted accounting for the greatest percentage of variance in the items, the following factor accounting for the variance not included in the first factor, and so on until all of the variance between the items in the domain could be explained.

Extracted factors were also subjected to an oblimin rotation (assuming the factors exhibited correlation) to simplify columns of the loading matrix and facilitate the interpretability of the factors. In addition, Kaiser's normalization was used to equalize communalities temporarily while rotating. In consideration of the small sample size, the researcher used the Kaiser-Meyer-Olkin (KMO) Test to measure the shared variance in the items and, therefore, the suitability of the data for factor analysis. Each domain's KMO score (Table 7) reflected an adequate score, with collaboration, communication, critical/expanded thinking, creativity, and content mastery all yielding "middling" KMO scores (.70, .70, .70, .74, and .71, respectively), and digital literacy (.68) yielding a "mediocre" score (Beavers et al., 2013).

Table 7

Kaiser-Meyer-Olkin (KMO) Test Results for Each Domain

Domain	**Score**	**Interpretation**
Collaboration	.70	Middling
Communication	.70	Middling
Critical/expanded thinking	.70	Middling
Creativity	.74	Middling
Content Mastery	.71	Middling
Digital literacy	.68	Mediocre

Eigen values and scree plots were then used to generally determine the cut off points for items' inclusion under each domain. There is no consensus on the cutoff values that should be used to evaluate model fit, or even the best method to determine the fit of factors within EFA. It has also been argued that the use of absolute cutoff values is inadvisable because fit indices are influenced by elements of the research setting, including sample size and the quality of writing of the items in question (Costello & Osborne, 2005). Past researchers have noted that, in some cases, the loading on a specific factor cannot be explained based on an item's content, and that phenomenon manifested in the current instrument (Janssens, Wijnen, De Pelsmacker & Van

Kenhove, 2008). Therefore, the researcher considered content, ANOVA results, and post hoc test statistics for each item before making recommendations.

Ultimately, the researcher, aiming for "clean" factor structure, considered whether items loaded above .30, exhibited few or no cross loadings, and resulted in domains with more than three items in the EFA (Costello & Osborne, 2005). While consideration was given to scree plots and Kaiser retention recommendations (i.e., that eigen values were greater than one), these criteria were not looked upon as the sole determinants in explaining the item variance for the proposed dimensionality or expressing the strength of that support (Ford, McCallum, & Tait, 1986; Costello & Osborne, 2005). Through this style of evaluation, the number of items included in the final instrument was reduced from 34 to 31, and many recommendations were made for reevaluation of the items with a larger pilot testing sample.

Bias

Bias occurs when "systematic error [is] introduced into sampling or testing by selecting or encouraging one outcome or answer over others" (Merriam-Webster, n.d.). Bias can occur at any phase of the research process, whether in the planning/instrumentation development, data collection, or analysis phases of a project. While no researcher can effectively eliminate the bias in a study, research suggests that bias can be counteracted. The following section briefly addresses how bias was addressed throughout the current study.

Data Collection

The myth of methodology is the notion that by identifying just one "best method, we will progress rapidly toward our goals in research" (Maxcy, 2003, p. 78). A multimodal study, by the nature of its design, moves away from the myth of one best way of carrying out a study. Mixed methods studies, like experimental studies in the hard sciences, are based on multiple measures of a phenomenon (Yin, 2009). By presenting diverse and divergent views, the method ensures breadth as well as depth of data collected, increasing the reliability of findings and lessening potential bias (Teddlie & Tashakkori, 2003). Because mixed methods research employs different methods to “assess the same phenomenon toward convergence and increased validity”, triangulation is inherent to a multimodal study (Cameron, 2009, p. 144).

Planning/Instrumentation Development

As illustrated earlier in this chapter, a combination of data collection methods provided both convergent and divergent evidence about the studied phenomenon (Johnson & Turner, 2003), strengthening the power of the data collected. The use of a focus group interview protocol supported the use of consistent questions and order (Edmonson & Irby, 2008), decreasing interviewer bias. Intramethod mixed observation (Johnson & Turner, 2003) decreased the observer bias, which is a weakness of observations. In consideration of the lack of a widely available and accepted validated survey instrument for 21st century skills, it was important to minimize bias in the researcher-created survey of the current study, in part by pre-testing the survey (Edmonson & Irby, 2008). However, other techniques were employed throughout the study to ensure minimization of bias and are discussed below.

Analysis

Procedures suggested for counteraction of bias during the analysis phase include a code-recode procedure and peer examination. In a code-recode procedure, data are coded and then set aside for a period of days and then revisited for recoding. In using peer examination, data are recoded by an able peer (Edmonson & Irby, 2008). Both methods were employed in the current study to ensure that bias did not unduly affect the analysis portion of the current study.

Ongoing

Research is, in part, about creating new understandings and negotiating the meanings attributed to situations or interactions. According to Constance Fischer at Duquesne University (2009), humans live in accordance with meanings, and it is through experiences and reflection that individuals come to comprehend the world and develop meaning. Self-awareness, which is often accomplished through bracketing, or "setting aside" assumptions, allows the development of particular understandings of the biases being challenged and supported through research (Fischer, 2009). Ongoing reflexivity is essential to producing sophisticated research and was pursued throughout the current study as follows:

- the researcher identified and recorded assumptions and interests about the research topic both before and during data collection and analysis. The researcher frequently checked to see whether meaning was being superimposed on the data, and
- once finished with the evolution of reflexive reading of data, earlier understandings and assumptions were reexamined against emerging insights (Fischer, 2009).

The researcher also employed memoing to raise awareness of biases and assumptions. Memoing, which the researcher engaged in daily during data collection and analysis, supported reflection and analytical insight and increased engagement in self-critique (Maxwell, 1996). Increased reflection and insight led to self-critiquing practices and a heightened awareness of the effect of the researcher's biases and assumptions on the research process.

Conclusion

Chapter three has been devoted to an explanation of the current study's methodology. The study followed a mixed methods research design in which the qualitative phase drove the creation of an instrument to measure 21st century skills perceptions in high school students. The proposed scale generated quantitative data, which were analyzed using appropriate statistical procedures. The mixed methods approach strongly supported the primary aim of the study: to gauge perceptions of 21st century skill development in high school students and teachers engaged in one-to-one initiatives.

Chapter four presents the qualitative findings of the study and chapter five explains the quantitative findings. The sixth chapter contains an analysis of the findings as well as implications for schools implementing ubiquitous computer programs. In addition, chapter six will contain suggestions for future research.

CHAPTER FOUR

QUALITATIVE FINDINGS

The purpose of this study is to examine how high school students and teachers perceive 21st century skill development in relation to one-to-one initiatives. Concerns about students' preparation for college and future workplaces as well as the recent explosion in the availability of digital technology have contributed to an increase in one-to-one initiatives in American public schools, but knowledge about the effects of one-to-one initiatives has not developed in tandem with this increase (Chang, 2016; Penuel, 2006). One-to-one initiative research has shown that participating students make significant academic gains but also may be developing 21st century skills (i.e. communication, collaboration, critical thinking, creativity and innovation, and digital literacy) (Abell Foundation, 2008; Baines, 2015; James-Burdumy et al., 2009; Slavin, Lake, Davis, & Madden, 2009; Zheng, Warschauer, Lin, & Chang, 2016). The focus of the current chapter is on the qualitative findings of this mixed methods study. This understanding will inform the development of an instrument which will be validated in one-to-one initiative high schools. Those findings will be detailed in chapter five. Chapter six will focus on a discussion of chapter four and five findings and their implications.

Chapter four considers research questions one and two:

<u>Research Question One</u>: What outcomes are identified within an activity system in which one-to-one devices are the mediating artifact?

<u>Research Question Two</u>: What 21st century skill development is identified by students and teachers in an activity system in which one-to-one devices are the mediating artifact?

To answer research question one, the researcher coded one-to-one initiative outcomes of teachers and students, who were considered subjects in two different but related activity theory matrices;

overlapping objects were considered common system outcomes. To answer research question two, the researcher coded data related to 21st century skills, identifying significant themes in the data.

The remainder of chapter four is devoted to a brief description of each of the three data collection sites, including the environments and contexts under which data were collected. Information about the observations, focus groups, and teachers interviewed will also be provided. Finally, relevant findings and their implications for instrument creation will be presented. Chapter five will detail quantitative findings related to the instrument's validation process, and chapter six will be devoted to a discussion of the implications of the study for high schools, which will conclude this dissertation.

Data Collection Sites

Two public high schools and one private school participated in the qualitative data collection, which occurred between January and May 2018. Each school was assigned a computer-generated pseudonym—Willow Mount High School (WMHS), River View Academy (RVA), and Green Lake Senior High School (GLSHS). Table 8 summarizes features of the participating schools.

Table 8

Characteristics of Participating High Schools

School	**Green Lake Senior High School**	**River View Academy**	**Willow Mount High School**
1:1 device	Chromebooks	Dell Laptops	iPads
Academic achievement indicators (% proficient or advanced on state assessments)	Math 75.51% English 84.26% Science………. 86.15%	Math 72% English 82% Science 73%	##
Accredited	Yes	Yes	Yes
Building level academic score	81.2	**	**
Free/reduced lunch rate	39%	50%	N/A
Geographical classification	Rural	Urban	Suburban
Location	Northern Appalachia	Southeast	Mid-Atlantic
Professional development around technology (as described in interviews)	Google Teacher Academy, teacher-led, ongoing	Individually sought, pursued on teachers' time, ongoing as desired by individuals	Offered before starting the initiative, not ongoing
Public/private	Public	Public	Private
Student body	~850	~1700	~400
Student-teacher ratio	14:1	16:1	12:1
WiFi availability	Within school building	Within classrooms and common areas	Indoors and outdoors throughout campus
Yrs. 1:1 in place at time of study	3	17	5

Note. ****** No building-level academic scores available as these institutions do not calculate this statistic; ## No testing scores available as this institution is not required to report these figures

These research sites varied in terms of architecture, demographics, economics, and geography, reflecting the diversity in the communities around them. However, across the three research sites, commonalities existed. Each of the three schools had a published mission statement, vision, or set of standards that suggested institutional support of the 21st century skill set. Additionally, each school provided generally reliable school Wi-Fi and virtual and physical spaces to support student collaboration and communication, although the accessibility varied widely across the three sites.

Green Lake Senior High School

Green Lake Senior High School (GLSHS) is a public high school serving students in grades 9-12. Located more than 60 miles from a major urban center in the northern Appalachian area of the United States, GLSHS is classified as a rural school and serves a predominantly White student population (88%) in a school of about 850. Approximately 39% of students receive free or reduced lunch. GLSHS's student-teacher ratio is 14:1. At the time of writing, GLSHS was accredited by the Middle States Association of Colleges and High Schools.

GLSHS's Chromebook initiative had been in place for three years previous to the study with the stated aim of leveraging technology for educational purposes and promoting the ISTE Standards. According to the GLSHS's technology plan, the one-to-one initiative's goals include providing real-life relevance of studied information, differentiating instruction, and giving equitable technology access to all students in the high school. The district supported the initiative with professional development, launching the program with a group of "beta teachers" who trialed the integration of the classroom technology before the devices were available on a one-to-one basis. In addition, the district supported a group of teachers in attending the Google Teacher Academy and pursuing Google certification. In addition, the district offered ongoing professional development around technology in part through teacher-led technology seminars.

The GLSHS curriculum follows its state's Common Core Standards, and students are able to take advanced placement (AP) and honors classes as well as dual enrollment (DE) courses. In addition, GLSHS offers an in-house cyber option for students which blends traditional course work with various options, including in-school online course instruction and off-site cyber-based course instruction. According to the GLSHS website, the purpose of the cyber option is to offer students an education that prepares them for the future, aligning strongly with 21st century skills rhetoric.

According to GLSHS's state's reporting system, the majority of students tested in the school in the 2016-17 academic year scored at proficient or advanced levels on statewide assessments. In math, 75.51% scored as proficient or advanced, while in English 84.26% of tested students reached that standard. In science, 86.15% of students passed state tests with proficient or advanced designations.

GLSHS's classrooms are housed entirely in two wings of an enclosed two-story brick structure. The school is encircled by playing fields and grassy areas. Students transition between classes within the shelter of the building, with minimal administrative or teacher supervision. A large open space on the school's first floor houses student artwork, a school store, and a small café and coffee bar. The area was also recently renovated to support a welcoming environment for student communication and collaboration; however, this area was designated as being for the exclusive use of the senior class. Lunch periods are staggered. School Wifi is available throughout GLSHS's building.

River View Academy

River View Academy (RVA) is a public high school serving students in grades 9-12. Located within ten miles of a major urban center in the southeastern United States and classified as an urban school, RVA attracts students from the surrounding geographical area but also houses an International Baccalaureate (IB) Diploma Program; thus, students who are accepted into this specialty program may attend the school even if they do not live within the school's geographical boundaries. RVA's faculty serve a student population of about 1,700 with a student-teacher ratio of 16:1. The student body is predominantly Black, Hispanic, or Asian (89%). In total, 50% of students receive free or reduced lunch. In the 2017-18 school year, RVA was classified as a fully accredited high school by the state's department of education.

RVA's one-to-one initiative, in which all students and teachers are assigned Dell laptops, is part of a larger district-wide initiative. At the district level, the program has been in place since 2001. RVA's initiative, therefore, represents the most established initiative included in the current study. According to research notes on the RVA laptop initiative, the initiative's primary aim upon inception was to maximize the opportunity for students to learn by making them more active in a dynamic educational process. A secondary aim of the initiative was to grant equal digital opportunities to students throughout the district. The school's current mission as it relates to 21st century skills is to promote progress within the ISTE Standards and help students become critical thinkers, problem solvers, collaborators, and lifelong learners.

RVA teachers described professional development around technology as largely individually driven but well supported by the school and district. One teacher, for example, described individually attending a weekend-long conference on technology integration in the mathematics classroom. Unique within this study's cases was RVA's provision of a technology specialist in the school who worked full time to match available Internet-, hardware-, and software-based technology resources with teachers' classroom approaches and interests.

According to RVA's website, the laptop initiative contributes to a high-quality education that helps prepare students for a global society by actively involving them in their learning and promoting communication, critical thinking, and collaboration. The RVA curriculum emphasizes state standards but also, as mentioned earlier, offers the International Baccalaureate Diploma Program. In addition, the school offers arts-intensive education, DE courses, and AP and honors courses. According to RVA's state's reporting system, the majority of students tested in the school in the 2016-17 academic year passed their statewide assessments. In math, 72% scored a pass, while in English 82% of tested students reached that standard. In science, 73% of students passed state tests.

RVA, which sits next to a busy road, is a semi-open campus of rectangular brick buildings. Students transition between classes on sidewalks or across grassy spaces and are encouraged by faculty and administrators to move smoothly between bells. While the researcher was at the school, students organized and held a vigil in honor of the shooting victims of Parkland High School in Florida. Despite winter weather, students held the event on a school sport field due to concerns that the school's indoor spaces might not be sufficient to accommodate all participants. The researcher was unable during the visit to observe any other areas dedicated to student collaboration. Lunch periods are staggered. School Wifi is available throughout RVA's classrooms.

Willow Mount High School

Willow Mount High School (WMHS) is a private Christian interdenominational institution serving students in grades 9-12. It is accredited by a faith-based organization and by the AdvancED—North Central Association Commission on Accreditation and School Improvement. Located within 40 miles of a major urban center on the Atlantic seaboard, the school attracts students from the city as well as from the surrounding suburbs and rural areas. The annual tuition ranges from $13,150–15,995, and 88% of students receive some financial aid. WMHS has a student-teacher ratio of 12:1, with about 75% of teachers and administrators holding advanced degrees. The student body, which numbers just under 400 and is predominantly White, is also comprised of about 10% international students, most of whom are from China. Further demographic statistics were not available at the time of writing.

WMHS's iPad initiative had been in place for the five years prior to the study with the stated aim of providing equitable access to technology for all students and teachers as well as opportunities for active and engaged learning, practice in the responsible use of technology, and preparation for college life and future careers. According to the WMHS website, the one-to-one initiative helps the school address International Society for Technology in Education (ISTE) Standards of creativity and innovation; communication and collaboration; research and information fluency; and critical thinking, problem solving, and decision making. Interviewed teachers described minimal professional development around technology integration in their classrooms, with most of their professional development having occurred in the year before the initiative was implemented at their school. No teachers referred to ongoing development opportunities associated with technology in the classroom.

The school's curriculum is designed to build a strong foundation for life-long learning, academic knowledge, effective communication skills, creativity, and the use of technology—all of which align with the Partnership for 21st Century Learning (P21) skills framework (Battelle for Kids, 2019a). In addition, the curriculum emphasizes a global perspective, with community and peace building emphasized as a common thread throughout the students' four years. The school offers AP, honors, and DE courses, and online options are available for courses not offered at the school. Electives and faith-related options augment the curriculum. Learning support services are available for students who need them.

The WMHS campus, which is set at the end of a long tree-lined lane, is designed on an open model, with students transitioning across grassy lawns between classes. In addition to a large chapel, classrooms, and laboratories, within each of the school's many academic buildings are communal open spaces warmed by natural light and populated with cushioned seating. All students and teachers attend lunch simultaneously and are invited to use those spaces in addition to outdoor spaces at that time, as well as before and after school. School Wifi is available throughout the WMHS grounds.

Data Collection Procedure

The researcher collected qualitative data through six classroom observations, seven one-on-one interviews with high school teachers, and seven focus group interviews with 34 students at three high schools. The individuals at the three sites represent economic, social, racial, and geographical diversity, lending richness to the study.

Focus Groups

Focus group interviews involved 34 students (14 males and 20 females) representing grades 9–12. In total, 30 of the 34 students had been involved in the one-to-one initiatives for the entirety of their high school careers. The groups talked for between 25–90 minutes each. Focus groups ranged in size between two and seven students and occurred around a shared table in conference rooms, libraries, or empty classrooms. Only one focus group could not finish in the allotted time so completed their interview over two consecutive Fridays. Focus group participants were generally familiar with one another through classes, afterschool activities, shared classes, or clubs. All participating students' parents or guardians gave written informed consent (Appendix C) for their children to participate in the study. Students also gave written informed assent to participate (Appendix B). Characteristics of student focus groups appear in Table 9.

Table 9

Characteristics of Focus Groups by School

	Green Lake Senior High School	River View Academy	Willow Mount High School	Total
No. of FGs	2	2	3	7
No. of Students in FGs	n = 10 (FG 1 = 5; FG 2 = 5)	n = 9 (FG 1 = 4; FG 2 = 5)	n = 15 (FG 1 = 2; FG 2 = 6; FG 3 = 7)	34
Grades	9-12	12	10-12	9-12
Sex	n = 8 female n = 2 male	n = 4 female n = 5 male	n = 8 female n = 7 male	n = 20 female n = 14 male
Race	Asian White	Asian Black White	Asian White	Asian Black White

Classroom Observations and Teacher Interviews

Seven teachers agreed to classroom observations and subsequent interviews, but the researcher was able to complete only six of the observations due to a snow day and then subsequent testing dates. Observations lasted between 30–120 minutes. The researcher adapted the protocol, an observation checklist, from Henrico County's TIP Chart (n.d.) and the H.E.A.T. Rubric for Classroom Walkthroughs (Johnson & Turner, 2015; LoTi Organization Inc., n.d.). The checklist's specific observation factors included the identification of instruction and/or practice that promote or deny communication, collaboration, creativity, and digital literacy; the purpose of the implementation of the 21st century skills observed; the content associated with the skill implementation; and the delivery mode of instruction. In addition to the checklist, the researcher made notes during the observation with a focus on the physical classroom environment, interpersonal interactions, and the use of classroom technology. Observation notes and checklists were then coded for demonstrations of communication, creativity, and collaboration skills, and digital literacy.

Within 24 hours of observations, the researcher conducted one-on-one interviews with six of the participating teachers, and the seventh teacher who could not be observed also agreed to an interview. The four male and three female teachers were aged between 25-50 years and had taught for between 3-25 years. Teacher participants taught chemistry, physics, geometry, world history/world issues, statistics, civics/government, and English language arts (ELA). Only one teacher had taught exclusively in one-to-one initiative schools, and one teacher had joined his school specifically for the opportunity to work in a one-to-one initiative setting. Characteristics of participating teachers appear in Table 10.

Table 10

One-on-One Interviewee Characteristics

School	**Participant pseudonym**	**Always been 1:1?**	**Class(es) observed**	**Grade(s) observed**	**Sex**	**Years taught**
GLSHS	Mr. A	No	Civics/Government	9-12	M	12
GLSHS	Ms. Bee	No	ELA	10	F	20
RVA	Mr. Jay	Yes	Physics	12	M	12
RVA	Mr. Zee	No	N/A (geometry discussed)	N/A	M	3
WMHS	Ms. Em	No	Chemistry	10	F	15
WMHS	Ms. Gee	No	Geometry/Statistics	9-12	F	12
WMHS	Mr. H	No	World History/World Issues	12	M	12

Note. GLSHS: Green Lake Senior High School; M: male; ELA: English language arts; F: female; RVA: River View Academy; N/A: not applicable; WMHS: Willow Mount High School

Interviews occurred face-to-face, lasted between 20–45 minutes each, and were carried out in conference rooms, offices, or empty classrooms or corridors during the school day. The main aim of the interviews was to determine teachers' perceptions of skill development in each of the 21st century skill domains as they relate to one-to-one device use. All interviewees gave written informed consent (Appendix A) and verbal consent to participate in the study and were assigned a pseudonym.

The significant themes generated from the analysis of responses are organized and presented through (a) textural descriptions, or “What” participants perceived about each area of skill development; (b) structural descriptions, or “How” participants justified those perceptions and described the skills being supported or enacted; and finally, (c) a description of the “essence” of respondents’ perceptions (Creswell, 2007).

Findings: Research Question One

Research question one is “What outcomes are identified within an activity system in which one-to-one devices are the mediating artifact?” The researcher used data from student focus groups and teacher interviews to answer this question. To be considered for inclusion as an outcome, data had to relate to research question one and third-generation activity theory. Once irrelevant data were eliminated, the researcher determined outcomes based on utterances meeting at least one of the following criteria:

- An utterance had to be school- or class-related and in reference to something happening in the future as a result of learning or classroom activities (e.g. “Students will get better grades on their exams if they are able to use Kahoot to review.”).
- An utterance had to contain modal verbs suggesting possibility or obligation (e.g. “Students could find real world applications for a lot of what we cover in class if they were to look hard enough.”).
- An utterance had to contain a tag question suggesting the researcher’s or another’s agreement with the statement in question (e.g. “We can get good grades on tests if we take the quiz quickly enough, right?”)

After outcomes were identified within the data set, the researcher coded data through thematic, axial, and selective coding procedures. Two significant themes emerged from the data analysis—outcomes that are expected to occur while students are in school participating in a one-to-one initiative and outcomes of one-to-one initiatives that are expected to extend beyond students' high school careers. In-school outcomes were results, actions, learning, or thinking patterns that teachers and students identified or contextualized as occurring within students' high school careers. On the other hand, out-of-school outcomes were results or actions that teachers and students identified or contextualized as expected to occur beyond students' high school careers.

Teachers identified five different categories of outcomes that were occurring or were expected to occur as a result of involvement in high school one-to-one initiatives. Expected in-school outcomes were identified as students meeting curricular requirements/mastering content, engaging actively in learning opportunities, and becoming more independent "out of the box" thinkers. Outcomes that were identified as extending beyond students' school careers were real world skill development and expanded thinking abilities (Table 11).

Table 11

Teachers' Perceptions of Outcomes

Teacher Subject School	Ms. Bee ELA GLSHS	Mr. A Civic/Govt GLSHS	Mr. H W. Hist. WMHS	Ms. Em Chem. WMHS	Ms. Gee Stats/Geom WMHS	Mr. Jay Physics RVA	Mr. Z Geom RVA	
Categories/themes				**Frequencies**				**Total**
Expected in-school outcomes								
Meeting curriculum reqs./Mastering content§	6	1	4	10	6	3	3	33
Ss engaging actively in lng opps.§	3	5	3	3	2	1	4	21
Breaking Ss "out of the box"/Helping Ss become more ind. thinkers	12	1	1	0	2	2	1	19
Expected outcomes extending beyond school								
General skill dvpmt.§	10	7	9	5	17	16	8	72
Expanded thinking§	12	8	0	3	7	6	8	44
Subtotal	43	22	17	21	34	29	24	

Note. ELA: English language arts; GLSHS: Green Lake Senior High School; WMHS: Willow Mountain High School; RVA: River Valley Academy; §themes also identified by students; reqs: requirements; Ss: students; lng opps: learning opportunities; ind: independent; dvpmt: development

Students discussed seven categories of outcomes that were occurring or were expected to occur as a result of involvement in high school one-to-one initiatives. Expected in-school outcomes were identified as meeting curricular requirements/mastering content; easy, effortless, or speedy access to materials and course information; and engaging or fun learning environments. Outcomes that students identified as extending beyond their school careers were practical, real-world applications for learning; real world skill development; digital literacy development; and expanded thinking abilities (Table 12).

Table 12

Students' Perceptions of Outcomes

Foc. group (n)	1 (n = 7)	2 (n = 7)	3 (n = 2)	4 (n = 4)	5 (n = 5)	6 (n = 4)	7 (n = 5)	
Grades	11-12	11-12	10	12	12	9-11	10-12	
School	WMHS	WMHS	WMHS	RVA	RVA	GLSHS	GLSHS	
Sex	M/F	M/F	M only	M/F	M/F	M/F	M/F	
Categories/themes				**Frequencies**				**Total**
Expected in-school outcomes								
Ease/Effortless-ness/ Speed	16	0	5	2	1	1	9	34
Meeting curriculum reqs./Mastering content§	1	2	2	2	2	7	14	30
Engaging classes/Fun learning env. §	8	0	0	0	1	0	1	10
Expected outcomes extending beyond school								
Practical applications for content	8	5	8	6	2	4	8	41
Skill dvpmt §	2	2	1	6	13	2	9	35
Digital lit. dvpmt	3	0	1	2	3	1	9	19
Expanded thinking§	3	1	0	9	0	2	2	17
Subtotal	41	10	17	25	22	17	52	

Note. M/F: male/female; GLSHS: Green Lake Senior High School; WMHS: Willow Mountain High School; RVA: River Valley Academy; §: themes also identified by teachers; reqs: requirements; org. & info.: organization and information; env.: environment; dvpmt.: development.

Teachers and students identified four common expected outcomes from involvement in one-to-one initiatives: meeting curricular requirements/mastering content; engaging or fun learning environments; real world skill development; and expanded thinking abilities. In third-generation activity theory, these agreed upon outcomes are classified as "object$_3$" and are, therefore, the focus of the section that follows. The analyses of responses are organized and presented as “what” participants perceived about the one-to-one initiative outcomes, “how” participants justified their perceptions, and a description of the “essence” of respondents’ perceptions (Creswell, 2007).

Content Mastery

Meeting curriculum requirements and mastering content were most frequently mentioned by teachers as expected in-school outcomes of one-to-one initiatives. For students, this outcome was the second most frequently mentioned after “ease of access/effortlessness of accessing material/speed.” This finding was consistent with in-class observations, where all teachers focused strongly on content mastery.

What is content mastery. Both teachers and students associated content mastery with demonstrating command over and memorization of a body of knowledge. RVA teachers described content mastery extensively in relation to standardized testing requirements as did RVA students in both focus groups. However, in relation to one-to-one initiatives and the body of information available on the Internet, six of the seven teachers discussed this definition of content mastery as being obsolete yet necessary. For those six teachers, the ability to apply content to real world problems was more pertinent. Students defined content mastery as understanding what is right for testing purposes and focusing efforts as directed to reflect that understanding. Teachers and students at all schools described content mastery as an essential part of schooling, and teachers frequently mentioned it as an expected outcome of one-to-one initiatives.

How content mastery is supported/promoted. Observations in all schools revealed visually-rich learning environments. Students and teachers in all three schools operated in print-heavy, content filled environments. Mr. Jay’s classroom, for example, had small colorful 3D printer-created shapes littering desks, which had been the product of a recent unit which incorporated classroom technology, physics content, creativity, and problem solving (Figure 3).

Figure 3. Shapes designed and created in physics class using a 3D printer.

Mr. Jay also had bridges hanging from his ceiling which students had constructed throughout a quarter-long unit in which they represented their understanding of content and then tested their understanding by putting their designs through multiple trials (Figure 4).

Figure 4. The product of a physics-related project hanging from the classroom ceiling.

Similarly, Mr. A had lined his classroom walls with posters and pictures relaying information about the Bill of Rights and specific Constitutional Amendments. Ms. Em had an enormous periodic table of the elements that covered half of one wall as well as smaller student-created segments of the periodic table. Content physically surrounded students in all observed classrooms.

Teachers also indicated that students frequently interacted with new and reviewed content. All seven teachers stated that they introduce new target content at least weekly. Despite statements from six of the seven teachers about the importance of developing skills for future workplace success, all interviewed teachers acknowledged emphasizing content mastery over skill development, with one teacher noting that, “Students are spending a lot of time gaining information instead of applying information. We are light on skills and application of learning.” A second teacher echoed this sentiment, adding that a teacher’s job sometimes seems to be to “throw as much of that content at students as possible and hope it sticks.” In support of this statement, another teacher described the process of content mastery in high school as devoid of critical thought and inquiry. “Nothing against teachers, it’s just the curriculum itself has this constraint sometimes.” In contrast, however, one teacher stated, “there is a certain amount of knowledge that [teachers] have to give” for students to be successful in the subject area studied. Content mastery, she noted, is of primary importance. The same teacher perceived skills as unteachable and stated that the role of technology in content mastery was minimal. A more important outcome, she noted, would be that students have “the confidence to know that they can understand something.”

Six of the seven teachers talked about the power of school devices to help students master content, but only the two GLSHS teachers indicated integrating device use daily by weaving communicative and collaborative tasks with content requirements and curricular goals. Ms. Bee described her use of school devices as “personaliz[ing] students’ educational experiences, using an organizational structure…teaching them authentically within the assignments and asking students to…share with [a] partner or share with [the teacher] and I’ll get back to you…it allows for more communication that way.” Her colleague, Mr. A, noted that he used the devices to help the students master content by having them do “meaningful work…it is not just me speaking at them or to them, but it [is] us interacting. It [is] them interacting with themselves and it [is] them reading, writing, thinking, and speaking [about course content].”

The other five teachers indicated less frequent use patterns. Those teachers supported content mastery in relation to devices by giving students the choice of using paper or their devices to record content, instructing students to take guided notes from PowerPoint presentations, posting lesson plans and notes for students to access as study guides, providing practice assessments online, using school email accounts to reach out to students, and using programs to see where students struggle in order to tailor instruction. Assigning online videos or watching them in class and following with discussion or a lecture was also a way that teachers indicated supporting content mastery.

Students talked much more extensively about content mastery than teachers, focusing their discussions on how one-to-one initiative teachers support content mastery. All focus groups suggested that content mastery was an expected outcome in one-to-one initiative schools, and all students discussed this outcome in terms of an expectation for rich learning experiences marked by a balance of skill development and content mastery. Students stated that organized test preparation, critical thinking, and retention of material through meaningful, technology-aided repetition all contributed to content mastery.

Online videos, including from YouTube and Khan Academy, and general device use were mentioned most frequently as effective avenues for helping students master content (Figure 5). Digital sources of support (indicated in green in Figure 5) outnumbered non-digital sources (in blue) in students' perceptions of supporting content-related outcomes. A few students also mentioned unhelpful resources for content mastery, with PowerPoint and textbooks each being mentioned in two focus groups as undesirable resources for content mastery.

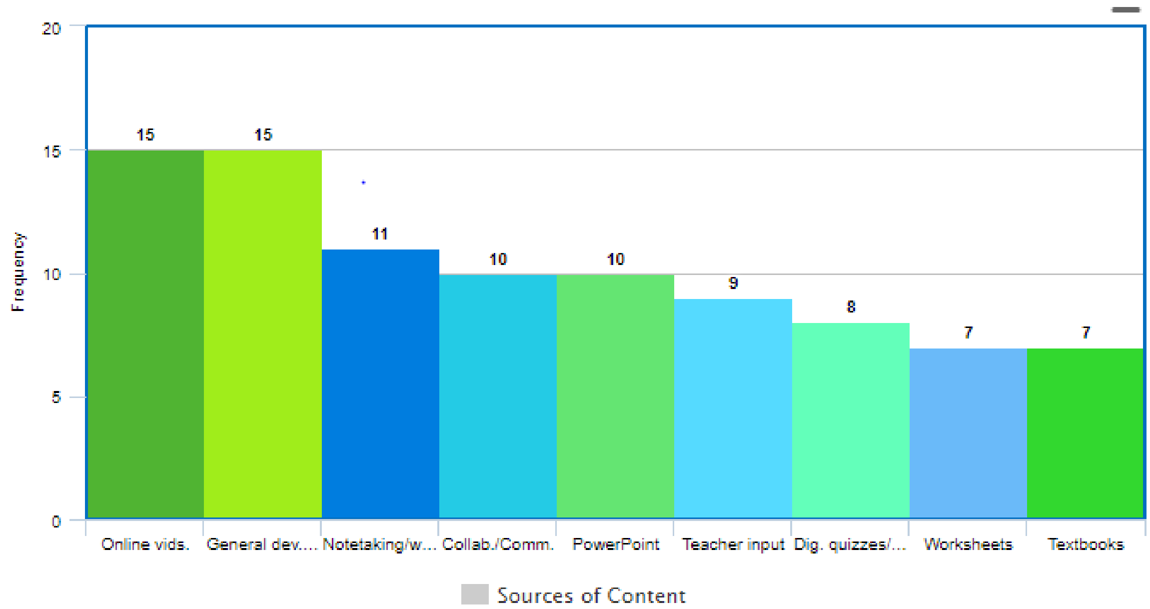

Figure 5. Frequencies of students' perceptions of effective content mastery resources. *Note*. online vids: online videos; general dev.: general device use; notetaking w/: notetaking with paper/pencil; collab/comm.: collaboration/communication with classmates; dig. quizzes: digital quizzes platforms (e.g. Quizlet, Kahoot, Nearpod).

Content mastery is an area that teachers and students similarly identified as an expected outcome of one-to-one initiatives. In reflecting on the expected outcome of content mastery in relation to one-to-one initiatives, teachers discussed feelings of conflict between emphasizing skill development versus emphasizing content mastery in their classrooms. All teachers acknowledged that developing skills and emphasizing content should be weighted equally in terms of instructional emphasis, especially given the value of skills in workplaces. However, most of the focus groups (n = 5) discussed the conflict between academic requirements (i.e. content mastery) and skill development, citing AP, International Baccalaureate (IB), and state tests as preventing students from having time to apply (not just master) content in order to develop skills. Most teachers interviewed (n = 6) also stated that content knowledge was the aim more emphasized by state testing requirements and, therefore, school administrators, lawmakers, and parents. Teachers noted that this emphasis trickles into classrooms, complicating skill applications in relation to content mastery.

The essence of perceptions of content mastery. Even though we live in the information age and the Internet places trivium at the click of mouse, content mastery remained a desirable outcome of schooling according to both students and teachers in the current study. Knowledge was seen as the basis for skill building, and teachers were expected to facilitate content mastery while students were expected to master that content. For teachers in the current study, one-to-one devices were described as optional (n = 4) or completely unnecessary (n = 1) for promoting content mastery in high school students, and teachers perceived themselves as the primary drivers behind content mastery. While four teachers suggested that the devices detracted from students' engagement with content at times, students viewed their school devices as effective and essential supporters of content mastery. Highly evident in students' perceptions of effectiveness, however, was the organization and presentation of materials within the digital realm. Whether the information was teacher, peer, or professionally generated, students perceived that the organization and easy accessibility of the material were important to their interest and abilities in mastering content.

Engagement in Learning

For teachers, the expectation that students would engage actively in learning activities was the second most frequently mentioned expected outcome of one-to-one initiative classrooms. In turn, students expressed an expectation that learning would be engaging when involved in a one-to-one initiative classroom. At the surface of this outcome, teachers and students seemed to indicate many common perspectives, but deeper analyses revealed fundamental differences in positions on engagement.

What is engagement in learning? All student focus groups and teachers mentioned that engagement was an expected outcome of one-to-one initiative involvement, and at the core of that engagement for both teachers and students was motivation. However, while teachers harbored a desire for students to engage in class because of their intrinsic motivation, students expressed a desire to be extrinsically motivated. Teachers described engagement as students being self-motivated to participate and remain focused on the classroom proceedings by asking questions, opening a dialogue with people in the classroom, and using feedback effectively. Students on the other hand, described engagement as something elicited from them.

Whether students were extrinsically or intrinsically motivated, both groups most frequently described engagement as being inspired by human interactions in the classroom. Five of seven focus groups noted the potential for devices to support those interactions. One GLSHS teacher, Mr. A, described the power of engaging students in class: “Technology is only helpful if it helps us become more human…[teachers] have to get out of the way sometimes” to let the students talk with one another. One student enthusiastically described that teacher’s classroom.

> And something I noticed is that the classes where you use Chromebooks more often have a better environ- uh, atmosphere…Mr. A’s…class is very interactive and…it would be less interactive if we were just paper and pencil because these Chromebooks are just an easier way to express your opinion to a large group of people.

Engagement in learning in one-to-one initiatives differed for teachers and students. While teachers expected engagement to be intrinsically motivated, students regarded it as something supported by external factors, including technology.

How engagement in learning is promoted. While students and teachers agreed that engagement was an anticipated outcome of one-to-one initiatives, they expressed very different views on how that outcome should be facilitated. Students described the teacher's role in supporting engagement as one of facilitator who is able to develop students' motivation in a variety of ways, including through effective technology use, direct instruction, and grades. Teachers, on the other hand, expressed a desire for students to engage in class because of their intrinsic motivation to learn.

All focus groups discussed their expectation that teachers should use technology effectively in class but also mentioned that teachers' abilities to effectively integrate technology to foster that engagement varied according to the teacher's age and subject matter taught as well as general interest in technology. Students at WMHS said

> Rob: A lot of the older teachers who have been teaching for many years without the iPad, they're like, I'm fine without it. And a lot of the teachers have been able to..use it to a lot more of its potential, like setting up group activities with like Google Docs or something or Slides…We use it, like, none in…English, unless we like finish early and then we just go on our iPads.
>
> Sandie: I think it just depends on the teacher. Like I have [one teacher] and she loves like doing discussions. So she'll have us watch videos on the iPads and just like do discussions.
>
> Felix: Science is like [we don't use it]. Math you just use it just to submit homework.

Students at GLSHS noted similar variation with teachers:

> Sam: Well what I said is that there's a definite divide with the teachers…like our civics class where you know you come in everything is online? There's rarely any paper-pencil work then there's like math class where the only technology used in the room is [the teacher's] and he sometimes has the Smartboard on.

Alfonso: Or health.

Sam: Yeah it's very paper pencil. The tests are paper pencil, and the only homework you have is that because they're very opposed to using them.

At RVA, students described the devices being used in all classes, with teachers varying in their abilities to engage students.

Cal: There are times that [teachers] don't use [technology] properly [to engage]...where it's just repetitive…but I can't blame them.

Researcher: What would be proper use?

Cal: You see but if the teacher finds a way to use the technology useful[ly] that makes you engaged. Then that’s using it properly. Showing you a Power Point every day is not, it’s going to bore you eventually.

Mike: But it's I- I- I think the PowerPoint aspect of classes, it's it's kind of hard to avoid it. I mean you have to present your information somehow in an organized manner? I think that's honestly the most effective way to [do it], especially because you can review later when studying for tests.

Cal: But see if you use…the technology in a different way it doesn't have to be PowerPoints. You can make a graphic organizer or something.

Jyoti: I feel like it’s the teacher’s skill…and I guess Power Points are technology that just aid [the teachers] or just amplify their already existing talents, or just not really help them at all.

Engagement, while expected, was not seen as entirely dependent on school devices. Students saw teachers as essential in the engagement equation.

Both RVA focus groups excitedly described how many of their teachers had recently incorporated engaging approaches and problem solving with school devices to help the students engage more deeply with content and one another. Breakout boxes, which RVA students described as “an escape room but in a classroom setting,” required the students to solve clues in websites or worksheets, collecting hints to crack locks and codes “to gain knowledge throughout the course of completing the breakout.” Students perceived breakout boxes as an engaging and unique approach to incorporating devices into learning.

All students suggested that abilities with technology combined with effective pedagogy made classes more engaging, but they also acknowledged that teachers could not always engage students. At all three schools, students stated that the teacher cannot do everything—students needed a fundamental interest in the content being presented as well as interest in actively participating in class.

Students at all three schools recognized the importance of grades in motivating them to engage in learning and skill development. One student at RVA expressed the importance of being externally motivated with grades. “The reason why I started [public speaking] was not because I wanted to be a better speaker. It was for the grade.” His classmate agreed, adding, “Like some people barely ever talk in class and they give a presentation—it’s amazing! They are after the grades.” Grades emerged as an important motivator for engagement in one-to-one initiative high schools among interviewed students.

Teachers had an opposite perspective on engagement, expressing a desire that students become intrinsically motivated to engage in learning. One WMHS teacher stated, “Motivation [is] wanting to engage with what you're doing out of intrinsic motivation and not just for the grade…or jumping through hoops. But [the student should be] wanting to really be motivated to [learn] whatever the topic is whatever the class is.” Ms. Bee at GLSHS suggested that intrinsic motivation might be fostered by a mindset shift:

> And I keep telling [the students] I want you to help build the hoops, because if you can build the hoops, you'll be successful no matter what. If you're just jumping through mine and waiting for my approval that's not going to get you where you want to go. Not anymore.

Teachers indicated that students being able to do more as a result of one-to-one devices was possibly facilitating intrinsic motivation and, therefore, more engagement. Mr. A pointed out, "The kids can look things up [with their Chromebooks]; in my opinion they're more engaged and…they're doing more." Mr. H noted that same engagement and added that his school's iPad initiative allowed students to do more in class more easily. "[The iPad gives] more practice for the students getting out and getting their own information and less of me the teacher standing up there and having [this funnel] through me." Although teachers did not mention students being intrinsically motivated, they recognized engagement as an important outcome of high school.

An interesting subtheme that emerged in discussions of engagement in one-to-one initiative schools was how students use their devices to disengage during class. All focus groups discussed how students (including themselves) used devices to game, online shop, or communicate with peers during instructional time. However, students also described "engaged disengagement," or disengagement that occurred around independent online research in response to class discussions and in-class fact checking. Students in GLSHS explained their engaged disengagement during in-class discussions and debates, explaining,

> Sam: Whenever I have down time [in class] I do full like research paper-worthy amounts of research…so like when something comes up in class and I'm like, I'm not quite sure

about that, I will do full on in-depth research like in the middle of class just for no apparent reason.

Researcher: So like where do you go…for that research?

Sam: During class if it's classwork I'll go to Google Scholar actually and I'll find out like the first things that come up, I'll start doing research to see if the site that the teacher got it from or something like that leans one way and if it has super biased information and then if I do I'll find something that's on the other side because once you start to see two different perspectives then you can build a better understanding of what they are trying to talk about…[and] I fact check people during our current events discussions.

Researcher [to Frannie]: Do you, do you take the same approach?

Frannie: Same thing. I don't do it during class…but like after school I might do it while I'm doing homework.

Dawn: I'll be like oh yeah I remember that and I'll look it up but I don't really like [either] during class but yeah [I do too].

At RVA, students also indicated their participation in engaged disengagement, explaining that starting in their junior years, teachers had encouraged them to be skeptical of what they were reading, hearing, and viewing around them. As a result, they would undertake engaged disengagement.

Mike: I think it's the generation itself, because we have such an easy and accessible way to look for information and loads of it, so our first approach is just Google.

Jyoti: Last year they did kind of teach us to question things right?

Cal: Yeah.

Mike: But at the end of the day, you got to figure it out.

Jyoti: Yeah but I don't know if they like, if it was anything new to me? but I guess maybe it reinforced the fact that I have to-

Cal: Make sure that everything is legit.

Although only indirectly related to class instruction, students' motivation to undertake research during class suggests that they may be engaging independently with learning content beyond teachers' awareness.

The essence of engagement. Teachers and students commonly recognized engagement as an expected outcome of involvement in one-to-one initiative high schools. Students expected teachers to facilitate their engagement through various avenues while teachers indicated that students should pull on intrinsic motivation to master content and develop skills. Students indicated an interest in external motivators for engagement but also described being distracted by uninteresting classes, independent inquiry, and the presence of an Internet-connected device. Analysis in this area suggests that bountiful human connectedness around shared content is fundamental to classroom engagement. Teachers can facilitate that connectedness through one-to-one devices, but WMHS students also accomplished the same end using poster paper and markers in a geometry lesson. Fostering this connectedness between teachers and students has long been an aim of school but, as noted by an RVA teacher, helping students foster these connections with each other requires students to do more in class, which he called "a big change." One-to-one devices afford students multiple avenues to make connections (e.g.., e-mail, learning management systems, chats, shared documents), making it a realistic outcome of 21st century skill building in one-to-one initiatives.

General Skill Development

Skill development was the outcome teachers most frequently mentioned during interviews and the second most discussed outcome in student focus groups. However, given the focus of the current study, this result is not surprising. While teachers and students discussed 21st century skills when prompted, they also discussed skills in more general terms outside of the questions that focused on 21st century skills. Teachers' and students' comments about non-21st century skills suggested real world abilities. Those data were open-coded, and those results appear in this section.

What are general skills? In response to the question, "Is high school more about developing skills or gaining knowledge," all teachers and students indicated that real world skills were anticipated outcomes of one-to-one initiative involvement, with "transferring academics to the real world," identified as the most valuable general skill to be developed in school. However, while teachers could identify ways in which skills developed in content-rich classes might transfer to the world beyond school, students could not make that connection in any focus group.

Students suggested numerous classes that are more skill-based than content focused. Students identified cooking, music, art, accounting, finance, business, and "anything that's not academic" as skills-based classes that are "useful for the workforce." At WMHS, two students pointed out that skills developed in school included conflict resolution although they did not name a specific class in which that skill was developed. At GLSHS, one student described sports as an important, emphasized skill, and a student at RVA noted that "how to be academically competitive" was an important skill fostered through his high school career. He saw this emphasis as especially valuable for his future university attendance.

In contrast, students identified physics, abstract math, chemistry, and biology as nonskills-based classes. According to four of the seven focus groups, for a class to be considered skills-focused, it should have real world applications and not emphasize content mastery; therefore, math and sciences could not be considered skills supportive. At RVA, GLSHS, and WMHS, focus groups mentioned that “skills should be promoted in school,” “skills-based classes should get more emphasis,” and “skills will help more than academics in the real world.”

Unlike students, teachers described technical skills (like computer skills) and finding information on Google as valuable real-world skills. Three teachers identified memorization as a non-essential skill in today’s digital world. Teachers at all three schools described skill development as being incompatible with testing and curricular requirements due to teacher beliefs that “skills can’t be taught,” “some people are just naturally skillful,” and “you can’t test [skill development] which means that it is difficult to teach.” Six of seven interviewed teachers stated that skills should be promoted more strongly in high school due to the need for skilled individuals in workplaces, suggesting perceptions that skills are underemphasized in one-to-one high schools. Both teachers and students discussed skills as an ideal to be striven for while knowledge was a cold reality to be dealt with in courses where content will be tested.

How skills are promoted. Students and teachers differed within focus groups and between interviews on how best to promote skills in high schools. One RVA focus group described skills as having to be learned through trial and error while academics were best learned through explicit instruction on content. However, within the other RVA focus group, students disagreed about whether skills can be taught in school.

> Mike: So public speaking and all of [those skills], schools can’t really teach that. It has to be more about general interest and it has to be where you are.
>
> Jyoti: It has to be your own initiative.

Susan: I think they can teach that…it was from what I got from the school that’s like I think that I've improved.

Cal: Yeah. Same. I used to be so, so nervous.

Mike: But you took the initiative to go in to [improve].

Students consistently disagreed with one another on the topic of schools’ abilities to teach skills to students, suggesting the strong need for more data in this particular area.

A few students in the GLSHS and WMHS focus groups settled on their schools placing emphasis on both skills and knowledge. One group of GLSHS students was involved in an especially lengthy discussion that noted the challenge of separating skills and knowledge.

Sara: Could I compare this to a school I've been to? so like, like in the Arabic world schools are really like more lecture… here we do a lot of fun labs, and, we actually use like papers and cut and stuff and I feel like I'm a child sometimes because like we don't have that back there. It's like you’re in college or something [in the Arabic world].

Hugh: I have no clue what classes you’re taking [but] that’s…showing the differences and like the different paths that can be taken here like skill-wise, and knowledge-wise…definitely there are two paths and they run like really close together…some of the classes are very lecture based and some of them are definitely where the teachers are trying to get you more involved in and into it.

Students held conflicting and varied views in the current study in relation to skills and knowledge in one-to-one initiative high schools. However, in every focus group, students indicated that they more strongly believed that their high schools were about mastering content than developing skills. One WMHS student called his state’s high school students, and his own classmates, “skill poor” and pointed out that real-world skills, like financial management, lack curricular emphasis in favor of less practical “knowledge-heavy” classes like physics and algebra which he maintained “I will never use.” Students from all three schools justified their beliefs that high school is about gaining knowledge by describing commonly assigned knowledge-based tasks—memorization, content mastery, answering standardized test questions, and tangibly demonstrating having learned material through quizzes, homework, and teacher-student question-answer sessions. Students also described how they perceived teachers supporting content-focused tasks through one-to-one initiatives and online platforms, but only two groups (one from RVA and one from GLSHS) discussed digital platforms for skill building, referring to Microsoft Office Excel and Word briefly.

The essence of perceptions of skill building. Although one-to-one initiative rhetoric promotes ubiquitous devices as avenues by which students can build skills and teachers can support skill development, students’ perceptions of school-based approaches to supporting skill development did not center around device use but instead focused on non-core classes. It is also important to note that none of the interviewed students identified skills which aligned with the 21st century skill set or involved one-to-one devices when asked through open questions about the skills they developed in high school. In contrast, teachers occasionally identified skill development in 21st century skill areas, perhaps because they have greater awareness of the specifics of the 21st century skill set and were influenced by their knowledge of the scope of the current study. As noted by many participants throughout this study, digital devices are tools that have the potential to support skill development, but students expressed the belief that effective promotion depends on teachers’ abilities to leverage technology effectively.

Expanded Thinking

This area was the fourth and final expected outcome that students and teachers commonly identified in relation to one-to-one initiatives. Although parties in all schools identified this area as an expected outcome of one-to-one initiatives, not all interviewees or focus groups did so. In this particular area, students' and teachers' perceptions of what expanded thinking is and how it can be supported aligned closely.

What is expanded thinking? Students who identified this area as an outcome of one-to-one initiatives described expanded thinking in terms of connection with others. They associated the concept with exploring others' opinions and thought processes. For students in one of the RVA focus groups, expanded thinking also involved meta-awareness. One student described an assignment in which the teacher supported meta-awareness with school devices: "We're…doing a project right now where we have to map out absolutely everything that we're like thinking about the project as we go along and a lot of that takes place on the laptops." For most students, though, the connection between expanded thinking and the use of their devices was about better understanding others' thinking by improving awareness and expanding perspectives instead of growing more aware of their own thinking.

In addition to discussing an expanded mindset as being essential to academic development and understanding others, teachers defined an expanded mindset in students as self-awareness. Two teachers observed that student familiarity with abilities and learning patterns were instrumental to students expanding their mindsets. Ms. Em and Ms. Bee pointed out that students need to think about how to learn from failure in order to be successful in the future. Ms. Em did not connect supporting that learning with school devices. Ms. Bee, in contrast, noted that learning to maintain a growth mindset was an important component of expanded thinking and one that easily incorporated school devices.

How expanded thinking is promoted. Not surprisingly, students in all focus groups indicated that expanding input beyond that of a classroom teacher via school devices led to greater understanding of thought processes and better awareness in general. Students also described their school devices as providing a portal to information, contributing seemingly unlimited perspectives to the educational process for those who could understand how to use keywords and put the effort into searching. Students from all three schools indicated watching videos to help them better understand content, and one student at RVA explained that she often used video-based content in place of reading textbooks.

Differing perspectives were not only seen as coming from the larger Internet community, Khan Academy, and YouTube. RVA and WMHS students described gathering opinions from other students in the school or district communities through Google Forms, Padlet walls, or Schoology's messaging system. WMHS students also discussed teachers facilitating school-based communication through Schoology and opinion sharing through Google Docs. Exploring others' opinions, according to one GLSHS students, made learning more interesting.

All seven focus groups and six of the seven teachers pointed to online security features occasionally interfering with their abilities to access information and, by extension, their abilities to expand thinking. One student remarked that putting restrictions on Internet access (as was done at all three schools) was not helping students learn how to deal with a world of information and challenges to thinking or morals. While students acknowledged many security features and blocks on their school devices, they did not see them as barriers to finding the information or perspectives for which they were looking. All student focus groups explained that they could easily circumnavigate blocks on their devices by using personal devices, installing virtual personal networks (VPNs), or asking a tech-savvy friend for help. As a result of this circumvention, many students suggested that their perspectives on the possible and impossible had shifted in relation to technology use.

Teachers also described the benefit of school devices in relation to expanded thinking. Mr. Zee at RVA observed that "devices allow students to think a lot more than paper-pencil" because the added visual stimulus and richness provided by a device gave students more to think and talk about. Mr. Jay expanded this idea of a richness of thoughts in relation to device use:

> A week ago…I showed them…SpaceX's Falcon heavy launch and [Elon Musk] put his convertible on the top of his rocket and he had launched it...So I showed them that then what happened was they were interested in [SpaceX]...And last week Tuesday's warm up both had to do with introducing them to Neil deGrasse Tyson and more about astrophysics so now they're now they- they're starting to ask me questions: "These pictures that you're showing us of these galaxies and these clusters, they're not real, right? These are made right?"

The devices played a fundamental role in students developing inquiry and awareness and expanding their thinking in unanticipated ways. Mr. Jay pointed out, however, that his class was not subject to state testing requirements, so he had the latitude to help students pursue inquiry through one-to-one device use.

Despite these perceived benefits in expanding students' thinking, Ms. Em acknowledged rarely using the devices in class in any way. Similarly, Mr. H indicated feeling that he was not using the device to its full potential. In addition, GLSHS students indicated the limitation to thinking brought upon by ubiquitous access to a device and the Internet.

Maury: Like you always Google something even if you- even if you think you know the answers because it's there.

Chris: Yeah it kind of makes you kind of unsure of yourself.

Maury: Like just last period I Googled what a gene was.

Chris: Did you really? That’s fundamental biology.

Maury: Because I was like, I wanted to make sure I get it right but um without messing up and I like, I was pretty sure what the answer is but I didn't want to mess it up.

While participants observed that school devices hold the potential to expand thinking, they also conceded that the devices might play a role in distracting students from thinking deeply or independently.

Essence of expanded thinking. Expanded thinking is a desirable student outcome of one-to-one initiatives, and one that both students and teachers perceived as resulting from ubiquitous computing programs. While school devices hold tremendous potential for opening a world of information and opinions to students, it may not be realistic in some classes to ask students to engage in activities intended to expand their thinking. When academic achievement and content mastery receive more emphasis than critical thinking, inquiry, and exploration, tasks that facilitate expanded thinking might be delayed until another day or another unit. Teachers from all three schools and one RVA focus group noted that genuine thinking is lacking when lessons are built exclusively around teachers explaining ideas that must be mastered due to testing requirements.

Summary

In answer to the question, “What outcomes are identified within an activity system in which one-to-one devices are the mediating artifact?,” four common significant themes emerged.

Students and teachers identified content mastery/meeting curricular requirements, active engagement in learning opportunities, general real-world skill development, and expanded thinking and awareness as commonly expected outcomes of one-to-one initiatives. Students indicated that their Internet-connected devices were helpful for accessing YouTube, Khan Academy, and quiz platforms (e.g., Quizlet, Kahoot, Nearpod) to review material that had been covered in class. Teachers noted that school devices can give students quick and easy access to sources of external research and content-related information during class discussions and activities. Teachers perceived that such access saves time that was previously devoted to trips to the library to search reference materials and enriches classroom discussions.

Both teachers and students also identified active engagement as an expected outcome of one-to-one initiative classrooms, although opinions differed between the two participant groups in relation to the nature of that engagement. Students indicated desiring fun, interesting, motivating classes by teachers who can use technology masterfully. Teachers discussed a desire for students to be intrinsically motivated to connect with one another digitally and face-to-face with rich contributions to the classroom's proceedings.

A third expected outcome for both students and teachers was general real-world skill development. Within focus groups, students disagreed frequently about whether their schools already enacted this outcome. Teachers also differed in their perceptions of whether their schools were offering general skill development opportunities for students. Teachers and students generally agreed, however, that real-world skill development is a desirable and realistic outcome to be expected in one-to-one initiative high schools.

The final expected outcome common to teachers and students was expanded thinking. Both groups of participants recognized one-to-one devices as supportive of explorations or other perspectives, expanded communication opportunities, and access to richer banks of knowledge than could be delivered without the presence of ubiquitous devices. Security features and limited device use, however, were both seen as common barriers to this outcome.

The four outcomes commonly identified by teachers and students suggest the potential for one-to-one computing initiatives to deliver outcomes that incorporate and extend beyond academics. Both teachers and students suggested expectations that these outcomes occur in school but also extend beyond the classroom into post-secondary experiences. Outside of discussions about 21st century skills, however, neither teachers nor students referred to such skills as expected outcomes of one-to-one initiatives in high schools. The second research question will further explore 21st century skill development in relation to one-to-one initiatives.

Findings: Research Question Two

Research question two is, “What 21st century skill development is identified by students and teachers in an activity system in which one-to-one devices are the mediating artifact?” To answer this question, the researcher used data from student focus groups and teacher interviews. In addition, the researcher looked to observation data to confirm descriptions of skill support. After 21st century skill sets were identified, the researcher coded the data through thematic procedures. Within each of the 21st century skill sets, separate themes surfaced, suggesting different levels of support for, and varying approaches to collaboration, communication, and creativity skills and digital literacy. As with the previous research question, analyses of responses are organized and presented through (a) textural descriptions, or “What” participants perceived about each area of skill development; (b) structural descriptions, or “How” participants justified those perceptions and described the skills being supported or enacted; and finally, (c) a description of the “essence” of respondents’ perceptions (Creswell, 2007).

Collaboration

Battelle for Kids (2019b) defined collaboration as the ability to "work effectively and respectfully with diverse teams; exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal, assume shared responsibility for collaborative work, and value the individual contributions made by each team member" (p. 5). Teachers' and students' definitions of collaboration largely paralleled those found in the Battelle for Kids literature, although they also expanded on it while explaining the ways in which collaboration is promoted in one-to-one initiative high schools. Discussions of how collaboration is supported conveyed a recognition of the variety of ways in which students and teachers can collaborate.

What is collaboration? When defining collaboration, students and teachers contextualized the skill largely around the actions of students working together online or face-to-face to achieve an academic goal through both directed/facilitated and independent approaches. Teachers described directed/facilitated collaboration as collaboration directed by teachers through assigned parameters defined by rubrics or other explicitly stated expectations. During directed/facilitated collaboration, students expected teacher feedback. In contrast, independent collaboration was contextualized as a student-driven undertaking that may or may not occur around content mastery. In independent collaboration, students did not expect teacher feedback or even teacher involvement.

All focus groups and four teachers used the words "students working" to describe collaboration without qualifying the action as effective. Two teachers pointed out that teachers can be a part of students' collaboration through facilitation or direction. All student focus groups also discussed collaboration as a self-initiated action undertaken independently through school devices and platforms commonly used in school-based collaboration. Students discussed this type of collaboration as involving other students in the school or school district.

Interestingly, four teachers defined collaboration as teachers working together to deliver more creative classes. Within this definition, teachers talked about this type of collaboration as an action that benefits students through the open flow of ideas and abilities to deliver more engaging classes. One WMHS teacher also classified collaboration between teachers as beneficial because of the potential for such interactions to model effective collaborative practices for students.

More than any other 21st century skill, students discussed collaboration in relation to mastering subskills, including abilities of compromise, persuasion, and understanding how to work with conflict. Teachers' definitions of collaboration, in contrast, incorporated other 21st century skills, including communication and digital literacy. In addition, teachers' definitions suggested a relationship between content and students' collaborative practices.

How schools promote collaboration. The two themes that emerged around types of collaboration were directed/facilitated collaboration and independent collaboration. While students talked about both types of collaboration in their focus group interviews, teachers restricted their discussions to directed/facilitated collaboration. Students undertaking directed/facilitated collaboration and independent collaboration indicated strongly incorporating school devices into their processes.

Students and teachers spoke most frequently in interviews on directed/facilitated collaboration. In this type of collaboration, the teacher had students work toward well-defined goals and encouraged collaboration to occur around teacher-provided assignments. Four student groups discussed approaching directed/facilitated collaboration by breaking an assignment into pieces, each doing their parts, and then stringing their answers together to present a completed assignment for a grade. Students identified external outcomes, such as grades or recognition for winning a game, as important and sometimes stressful motivators for directed/facilitated collaboration. Students and teachers most frequently identified Google Classroom or Google Suite as the online medium for directed/facilitated collaboration.

Student groups also discussed challenges associated with this type of collaboration. Students perceived most collaborative assignments as lacking a measure of student accountability, so students believed that teachers could not know who had done work in an online collaborative assignment. In focus groups, participants remarked that some students were awarded grades for minimal effort. Another challenge students identified was related to trusting peers to manage time appropriately in order to meet assigned deadlines and teacher expectations around quality of work.

Mike: One [challenge] well in the sense of work it's, it's work ethic.

Jan: Yeah like everyone should do their part.

Mike; Yeah it's not just that. It-

Laura: It's also hard to trust other people…Because yeah for me I feel like I can do this like my way will be, I'll be able to get a good grade.

Mike: Uh-huh.

Laura: If we do it my way and it's hard to let other people, take responsibilities too, and so it's, I don't know it's hard to collaborate and just giving up like a little bit of that trust knowing that they're going to be able to do what they're supposed to do.

Interpersonal relationships and trust emerged as having an important effect on students' abilities to collaborate effectively; however, students indicated culturing trust independently outside of the classroom and learning through trial and error how to be trustful with one another.

Teachers' roles in this type of collaboration included setting the assignment parameters, giving feedback, and supervising students in class, but students did not mention teachers helping them to develop skills around collaborative practices. In addition, students did not describe teachers' roles in directed/facilitated collaboration collaborative in nature. Two focus groups noted that teachers often discouraged collaboration due to its incompatibility with individual testing requirements.

Students also discussed independent collaboration as being supported through their school devices. Focus group participants generally described this type of collaboration as self- or peer-motivated, classifying it as supporting independent writing projects or independent research interests. One GLSHS student, Sam, described independent collaboration as "sharing crazy ideas between friends" for out-of-school fantasy fiction writing and peer editing through Google Docs. Students at RVA and other students at GLSHS also described independent collaboration undertaken through their school devices to prepare for exams. Juniors and seniors from both high schools described classes of students taking the initiative to create and share test review packets through Google Docs. Students indicated that using the comment feature in these shared Google Docs also allowed them to provide feedback on the correctness of information to one another and to discuss further links (e.g., in Quizlet or Brainly) for review.

Four teachers interviewed talked about collaborating with colleagues when asked to define the term; however, no students mentioned teacher-teacher collaboration. Of the four teachers who discussed collaborating with colleagues, only one WMHS teacher was involved in a professional collaboration at the time of the study. Teachers noted that collegial collaboration was supported by subject area within their schools (e.g., physics teachers collaborated amongst themselves, math teachers collaborated with other math teachers) and was further promoted by physical proximity of teachers' classrooms or shared lunch or planning periods. However, teachers did not discuss collaborating with other teachers via school devices.

Given the standardization that has occurred in recent years around standards and assessment, it was interesting to hear the amount of variability students and teachers perceive in approaches to collaboration. All interviewees acknowledged teachers' diversity of approaches to classroom collaboration. The GLSHS civics teacher supported students in collaborative online and face-to-face discussions around covered content while a WMHS teacher led World History students in a Socratic seminar, which is collaborative in nature, on a shared article. A second WMHS teacher had students work in small groups to solve geometric proofs. At RVA, students collaborated through Google Docs to answer questions during a warm-up activity. At GLSHS, Ms. Bee connected personally with every student during each class observed to give some type of feedback. At RVA, Mr. Jay did not have a chair at his desk so that he could better circulate and give students ongoing feedback on their skill development. In contrast, in one WMHS classroom, the teacher indicated intentionally providing few opportunities for collaboration due to the time such skill building takes from content mastery.

This diversity of approaches was also noted in the seating configurations, which varied widely by classroom. Seating was organized with between two and five students sitting at tables or desks, and one teacher using a circle to facilitate discussion. In the six observations undertaken, half featured teachers leveraging device use to support student collaboration through Google Docs, Google Classroom, and Kahoot.

Mr. H suggested that what many teachers call collaboration is actually direct instruction. Based on anecdotes that focus groups shared from their high school careers, it is likely that skill building in collaboration is not as present as observed. Students from RVA and WMHS discussed how they had struggled in school-based collaboration and how they had learned through trial and error the importance of compromising or working with conflict, suggesting that their lessons in each had been learned through trial and error during classwork rather than through direct instruction or teacher feedback.

In support of the challenges of developing collaborative skills through trial and error, RVA students described a recent assignment in which they had learned about the nuances of collaborative practice.

> Mike: So in history class we had this group project…and we all agreed that…all the information would be up by like Sunday at like 1 p.m. and everyone would review it by 9 p.m. so that we could finalize it. So that was the night of the Super Bowl right? so I get home around 1 a.m. and I see that um there are like two questions that are entirely unanswered. So that's like a whole chunk of the research so of course I'm not going to take, like a 50 or a 75 on the assignment, right? So I go ahead and do…that work for the other people and then they get mad at me the next day for doing the work. I was like what we agreed we agreed it would be done by this time and it, they were like no we never agreed on that and so- one little error in…collaboration where, you, some people need to be more organized and they're going to have a plan to complete it and others will do it at the last second…Like obviously knowing me I'm not going to wait until then waiting for someone to finish their work so I guess people have different strategies I guess to complete their work.

The teacher's feedback on this assignment was limited to a focus on content while the skill of collaboration went unaddressed. One-to-one initiatives give students expanded abilities to collaborate outside of the physical school setting, but students seem to be developing skills in collaboration independent of teacher feedback through trial and error.

The essence of collaboration. Personal computing devices provide students and teachers with an outlet for extensive collaboration which all interviewees described as students or teachers working together. However, collaboration in one-to-one initiative schools varied according to teacher interest, testing requirements, and subject matter studied. Students indicated using their devices for directed/facilitated collaboration in response to teacher directions and to fulfill content requirements. In addition, students described pursuing independent collaborative efforts outside of teacher input. Collaboration, a skill students indicated learning largely through trial and error, involved complex and multifaceted interpersonal subskills. For many teachers interviewed, however, collaboration was not a skill to be developed but a means to an end—content mastery.

Communication

Like collaboration, communication emerged as an important theme in teacher interviews and focus groups, where it was described as essential for positive learning experiences in one-to-one high school classrooms. Battelle for Kids (2019b) defined communication as the ability to

> articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts; listen effectively to decipher meaning, including knowledge, values, attitudes and intentions; use communication for a range of purposes (e.g. to inform, instruct, motivate and persuade); utilize multiple media and technologies, and know how to judge their effectiveness a priori as well as assess their impact; and communicate effectively in diverse environments (including multi-lingual). (p. 5)

Participants in the current study defined communication similarly, with themes emerging around communication in the one-to-one initiative classroom for evaluative purposes and clarifying purposes. Student focus groups spoke extensively of both types of communication while teachers focused largely on communication within the realm of school-based tasks.

What is communication? When explaining how communication is supported in one-to-one high schools, student focus groups and teachers commonly described two types of communication development in one-to-one initiative high schools: communication for evaluative purposes and informative/clarifying communication. Teachers and students described evaluative communication as interactions intended to provide feedback and negotiate the credibility and interpretations of studied materials. Both groups described informative/clarifying communication as interactions intended to convey or clarify information. Additionally, during one-on-one interviews, one teacher described communication for problem solving, but neither students nor other teachers did so.

When defining communication, teachers contextualized the skill largely around speaking, listening, and writing, but also briefly touched upon the importance of the quality of students' discussions and of developing an awareness of others while participating in conversations. Interestingly, when discussing this skill, four teachers also justified why the skill is important, suggesting that they may have had to rationalize a communicative classroom before the one-on-one interviews. One teacher noted that students arrive in her classroom believing it is wrong to communicate with one another during instruction, so part of her instructional approach supports students in learning that communication is part of learning and "talking is not cheating."

Students' definitions of communication encompassed a broader range of abilities and avenues than teachers' definitions. Like teachers, students predominantly defined communication as talking between students. However, their definitions emphasized the importance of also being able to talk between groups, institutions, and places beyond the classroom. Talking with teachers was not part of their definition of communication.

Unlike teachers' definitions of communication, students' definitions incorporated a digital component, with all seven focus groups stating that communication can be defined as messaging, texting, emailing, or chatting, and two groups stating that communication means "interfacing with objects" (i.e. cell phones and other digital devices). Interestingly, students in two different focus groups disagreed with their peers, noting that digitally-based communication is inauthentic and challenging due to the ability of users to remain "hidden" or "silent" in communication, create avatars, or anonymize their contributions within online forums. This position suggests students' perceived importance of physical proximity as well as body language and physical cuing in achieving genuine communication. GLSHS students said,

> Hugh: [A challenge of communication is] the whole face-to-face thing, like a lot of people have like nervous habits form and it's just hard to talk to people sometimes.
>
> Sara: Yeah so like when you're outside school you really don't know how to talk to people.
>
> Rhonda: Having technology like the Chromebooks kind of inhibits our ability to communicate with each other on a more personal level…because we're so used to talking over social media or through texting.

These students' positions supported their peers' suggestions that communication's definition must incorporate physical, face-to-face interactions, and that these skills must be developed.

Finally, both teachers and students defined communication qualitatively, with teachers in particular contributing the majority of characteristics possessed by skilled communicators. In two focus groups, students noted that clarity and being "well-spoken" were important characteristics of communication. Teachers, on the other hand, emphasized “on-task discussion” and “meaningful conversation” as being important aspects of communication. Similarly, Mr. A stated that communication between students should be authentic rather than contrived for the purpose of completing an assignment and noted the potential for one-to-one devices to aid in creating an environment of authenticity.

How schools promote communication. During classroom observations, the researcher saw students communicating with one another and the teacher to complete assignments, using both face-to-face and digital platforms to facilitate that communication. Those discussions were on task, seemed meaningful, and were student directed in all classrooms with the exception of two WMHS classrooms where the teachers were observed giving mostly direct instruction. In one GLSHS classroom, Mr. A monitored students’ digital communication in real time at his desk via Google Classroom and physically approached off-task students or those generating poor quality work to give immediate individualized face-to-face feedback on the quality of their writing. In total, teachers were observed giving explicit feedback to students on their communication skill development in four of the six classrooms observed.

Both teachers and students suggested the importance of school devices when describing evaluative communication. Primary in discussions of evaluative communication was teacher-student and student-student feedback, and students from all three high schools described using the comment feature in Google Docs to communicate feedback to others on their writing. In addition, students talked about teachers making suggestions for improvement using the same features. Students indicated their appreciation for evaluative communication, noting its positive effect on their grades.

Felicia: The teacher, she can not only like make comments [in Google Docs] but suggestions, so then you can like read her suggestions and then just accept it and [the platform] just changes it….last year in physics we had a really big paper and we peer edited it but it was just like on paper [and not on Google Docs] so it's like you have to go home and make sure that you got all the changes and like I had a couple things I just had to capitalize…it was the Sun…I didn't do that sometimes and I got points off…if it had been on Google Docs…I would have been able to get all those but since it was just on paper I missed a few.

In addition, students indicated that this type of communication was beneficial in terms of time, convenience, and efficiency.

> Claire: Google [has]…kind of like ways to get everybody to interact on our iPads…
>
> Robert: So like we with our writing groups and our teacher we can add everybody [in Google Docs] and then they can make edits to them and it speeds things up a lot…
>
> Claire: It's just like convenient because [communication] can be on the iPad, it can be on the computer, it can be, you can even do it on your phone like it's just like everywhere, technology access.

Ms. Bee described communicating with students through Google Docs in order to improve writing: "On the weekend they can email me and they can say…can you let me know when you're on so that we can both be on the same document [revising together]." Ms. Bee in the same interview suggested an unanticipated benefit of digital communication for teachers—legal protection. "[When we work collaboratively online] it's appropriate and it's all kept anthologized so that you know we're both protected in that sense but at the same time they can get specific [help]." Using digital platforms helps students evaluate their work while providing a safety net in case of future questions of the appropriateness of student-teacher communication.

Teachers and students also discussed using school devices to evaluate the credibility of studied sources and then communicate their findings in class. Mr. H at WMHS discussed the research-related uses of iPads and their relationship to in-class communication:

> I can ask the students to do some research right in the classroom there with their iPads and then we would talk about where did you find that information? Is it credible or not? Um how do you know that. That type of thing and so before I couldn't just incorporate that into my lessons without having to take the whole class up to the library for example. So it's allowed me to I guess incorporate that kind of thing more often.

Students at all three high schools discussed the role of devices in developing their evaluative communication abilities, with their approaches to evaluating information following identical patterns. All student groups had been taught through middle and high school to approach doubtful information by searching online for two or three confirmatory sources and also seeking out a differing point of view on the Internet. When pressed about their approach if they did not have a device available, one student replied, "If you don't have a device, odds are you are not going to want to look up information--you're going to trust what you're hearing is unbiased."

All students and most teachers seemed to recognize the importance of an Internet-connected device in interactions intended to provide feedback and negotiate the credibility and interpretations of studied materials. Participants indicated that school-issued devices make information more easily available. In addition, respondents stated that chat functions in Google Docs make giving feedback convenient, resulting in perceptions of development in evaluative communication.

Informative/clarifying communication, or interactions intended to convey or clarify information, was the only 21st century skill that students explicitly stated had been developed through involvement in their high schools' one-to-one initiatives. All student focus groups discussed this type of communication, which they conceptualized as including public speaking, sending emails to teachers to gain clarity on classroom proceedings or assignments, and advising others on how to carry out tasks, as supporting skill development. One student described learning how to communicate via email through his school's one-to-one initiative.

> Maury: Until we got the Chromebooks we were halfway through the first year that we had the Chromebooks and I still didn't know how to send an email….I didn't understand even the email software or I didn't care or I didn't know what to do with it.
>
> Researcher: And you learned through?
>
> Maury: Experience. Yeah.

Similarly, RVA students discussed learning to communicate with and engage audiences in technology-aided presentations by watching their teachers use that technology and reflect on the quality of those presentations.

> Cal: You can use the technology in a different way. It doesn't have to be Power Points.
>
> Maria: I feel like it's the teacher's skill…I guess Power Points are technology that just aid them or just amplify their already existing talents.
>
> Cal: A major aspect of…effective presenting is their Power Points or presentation…They don't have much information…teachers that use them the best are able to build upon what's written on the screen…technology…is not the major way in which they teach information.
>
> Mike: Yeah, it's talking.
>
> Maria: Yeah, the communication aspect.
>
> Mike: Communication and practice also with many classes.

Just as students discussed collaborating through their school devices for reasons outside of school, RVA students also discussed using their devices to convey information on any number of topics not necessarily covered within the school's curriculum: "We use [devices] a lot for extracurriculars so like a lot of us are leaders in clubs so it's a great way for that board or the council or whatever to communicate, get their documents straight…plan for the future, communicate with sponsors." In addition, students indicated using the devices to communicate with one another about content covered, copying and discussing academic information from various sources to help with testing. One GLSHS student drew her process of learning; the illustration reflects the role of student-student communication in her learning process as well as the role of her school and personal devices. Additionally, her drawing shows that after the teacher has transmitted information in class, he is largely absent from the learning and skill development process. Communicating with peers and referring to online sources becomes more prevalent (Figure 6). Although the student interviewed indicated that the teacher did not explicitly ask that the devices be used in class, and even discouraged device use, the illustration shows how the student uses the devices to learn in collaboration with peers and online resources.

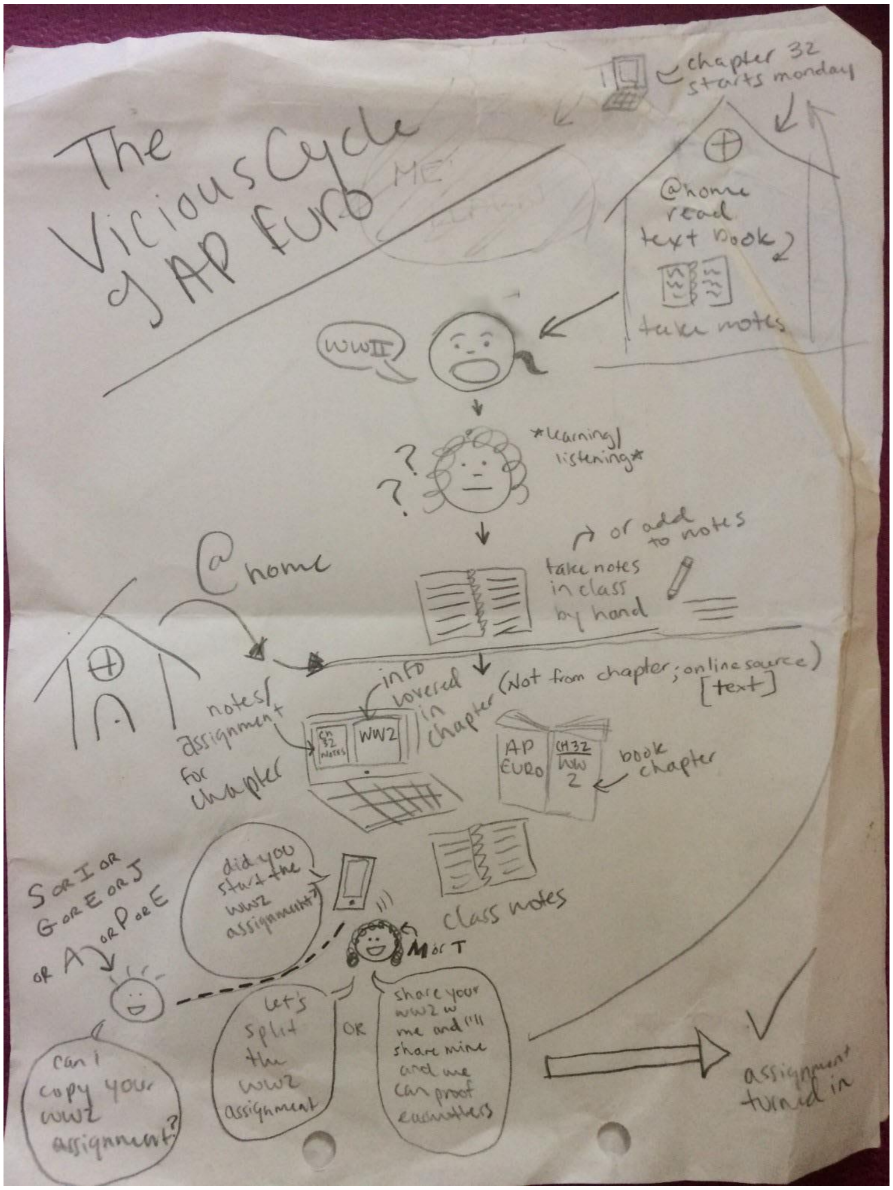

Figure 6. Illustration of the learning process in a one-to-one initiative high school class. *Note*. The teacher is centered (with a ponytail) and the student (with curly hair) is shown beneath the teacher.

The essence of communication. Students and teachers differed in their perceptions of one-to-one devices in relation to developing skills in communication for evaluation and clarification. While teachers did not define communication in relation to digital devices, all focus group students did. As with collaboration, students suggested developing communicative skills outside of teachers' awareness but while using school devices. These student-student interactions occurred around content-based assignments and integrated school devices into the process. Students also indicated learning the dos and don’ts of public speaking and presentation by watching teachers’ teaching styles and Power Point use. Teachers indicated communicating with students through school devices, giving feedback on the content being studied. Additionally, the researcher observed a teacher giving feedback to students on the quality of their communication in school assignments. Interview participants explicitly indicated developing communication skills of clarification more frequently than other 21st century skills. Given the close integration of communication with ELA and many social studies curricula, this finding is not surprising or unexpected.

Creativity

The Battelle for Kids P21 Framework (2019b) defines creativity in conjunction with innovation, conceptualizing it as an internal (thinking) process and an external (working) process that incorporates other people. Thinking creatively, or the internal process, involves generating ideas in many ways, including brainstorming, creating, and improving ideas through analysis and evaluation. Working creatively, or the external process, involves collaboration to “develop, implement and communicate new ideas” (p. 4). The external process also involves demonstrating originality, adopting accepting thinking habits, including openness and responsiveness to others’ perspectives and feedback, and acceptance of failure. The outcome of creativity should be “a tangible and useful contribution to the field in which the innovation will occur” (Battelle for Kids, 2019b, p. 4). Although elements of these definitions were present in teachers’ and students’ explanations of creativity (i.e., creativity as both an external and internal process), analysis revealed that teachers and students spoke of creativity as a largely academic endeavor, with additional artistic and technical elements.

What is creativity? In the studied schools, teachers and students conceptualized creativity as academic, artistic, or technical. Teachers and students perceived academic creativity as promoting content and described it as supported by tasks, creations, or expressions that reflect mastery and application of studied material. This type of creativity results from teacher-driven assignments and is undertaken with an audience (usually classmates) in mind. The products of academic creativity, which include but are not limited to essays and multimedia presentations, are often assessed based on a rubric which incorporates criteria beyond just creativity.

Artistic creativity does not necessarily relate to classroom content but incorporates traditional artistic expressions—sketching, drawing, painting, composing, and sculpting. At WMHS, one student noted, “individual creative endeavors that my classmates pursue online take away from their attention in class.” This student’s comments reflect the perception that this type of creativity serves no practical purpose within the academic classroom. In this situation, the products of artistic creativity are often created without an audience in mind but may appeal aesthetically to peers. Furthermore, assessment of this type of creativity comes through informal feedback from peers or through intrinsic valuations of the product.

Technical creativity may relate to content or individual teachers’ assignments but seemed to more often respond to the institutional constraints surrounding a student. Students and teachers described this type of creativity as resulting from attempts by students to problem solve, test the digital boundaries that surround them, or find previously unexplored digital avenues for accomplishing tasks. The products of this type of creativity are, according to a GLSHS student, “use of laptops in creative ways that admin doesn’t like,” including computer system workarounds, system hacks, and redesigned online systems or hardware. Students suggested that assessment of this type of creativity comes through an individual feedback loop, with successful expressions of this creativity paying off in the form of digital system control, shortcuts, or access to previously inaccessible digital areas, including district servers and school camera systems (Table 13).

Table 13

How Teachers and Students Indicated Developing Creativity

Academic Creativity	Artistic Creativity	Technical Creativity
Making multimedia presentations (T, S)	Digital and paper-based composing/painting/sketching (T, S)	Programming (S)
Writing tasks (T, S)	Creating physical models to represent concepts studied (T)	Coding (S)
Applying content to problem solving (T, S)		Creating hacks/workarounds (S)
Using online quiz builders (S)		Creating websites/wikis (T)
Creating rubrics (T)		
Participating in case studies/imagined scenarios (T)		
Formulating opinions (T)		

Note. T: teacher; S: student; *listed in each column from most frequently to least frequently discussed

When defining creativity, students discussed freedom, uniqueness, and exploration. In addition, they described creativity using vocabulary associated with actions and kinesthetic abilities rather than habits of thinking or mindsets. In contrast, teachers defined creativity in relation to thinking and written, verbal, and visual expression. In essence, students seemed to perceive creativity as a dynamic, external process while teachers perceived it as a cognitive, internal process.

Students described creativity as a cycle of inspiration, consideration, and doing occurring in an environment marked by freedom and uniqueness but noted that high school leaves little room for creativity because of testing requirements and the speed at which teachers must cover the curriculum. During a WMHS focus group interview, Stephen stated, “Creativity is the opposite of intellect, which is equivalent to fact, [and] art is a big part of creativity.” Stephen’s dual proposition, that creativity is largely represented by traditionally artistic pursuits, including painting, drawing, and sketching, while intellect incorporates reading, writing, and thinking, summarizes the perspectives of many other high school students interviewed. Students at RVA and GLSHS also recognized programming and coding as creative endeavors, although students at WMHS mentioned neither in reference to creativity.

Teachers also explained perceptions of creativity in terms of uniqueness but related creativity more strongly to academic abilities, including writing and critical thinking. At GLSHS, teachers described creativity as “the way you go about problem solving” and moving “beyond text in a manner that makes sense.” At WMHS, one teacher described creativity as “when students are able to express themselves.” Like students, though, teachers recognized limitations on creativity imposed by curricular requirements and the nature of knowledge. One GLSHS teacher stated, “creativity cannot and should not be present 100% of the time in the high school classroom, and developing understanding is very infrequently creative.” Of all the skills covered in this study, creativity was the one over which both students and teachers most frequently contradicted themselves, vacillating between its importance and unimportance in academics and its presence and absence in the one-to-one classroom.

How schools promote creativity. Interestingly, while both teachers and students perceived creativity as an innate unteachable skill, they also discussed and demonstrated many ways that schooling and one-to-one devices support academic, artistic, and technical creative development. During observations, the researcher noted that all teachers gave students opportunities for creativity in the classroom, but the level of creativity supported varied widely.

In two of the WMHS classrooms, students' creativity was limited to constructing questions about existing knowledge. However, in the third WMHS classroom, students collaborated to actively synthesize information to create new products while the teacher circulated around the classroom to give ongoing feedback on the level of creativity, collaboration, and communication demonstrated. None of those teachers incorporated school devices into those lessons. The observed RVA teacher also made great efforts to help students create products beyond teacher-defined parameters by asking students to create the rubrics for their final assignment in an online format. In total, three teachers were observed guiding students to use computers to help with the creative process, but only two were observed giving students explicit feedback on their creative processes. Despite this limited observed guidance of creativity, focus group participants described classroom creativity extensively, and all teachers described efforts to integrate creative approaches into their instruction.

When discussing how creativity is supported in one-to-one initiative high schools, both teachers and students discussed academic creativity more than technical or artistic creativity References to academic creativity shared by teachers and students included making multimedia presentations, writing tasks, and applying studied content to problem solving. Students indicated using online platforms to accomplish all of these tasks, with Google Docs mentioned most frequently followed by Power Point, Google Slides, and Breakout Boxes. Interestingly, students in the three schools conflicted in their views of Power Point supporting creativity. At HVA and in one WMHS focus group, students noted that Power Point presentations are "boring" and that "a school device gives more options for creativity than just Power Point," intimating that teachers could make more of an effort to find creative avenues for instruction. In contrast, one WMHS and one GLSHS focus group stated that Power Point presentations are inherently creative, although they did not elaborate on how Power Point supported creativity.

Teachers and students all discussed problem solving in relation to content as creative, with focus groups at RVA discussing breakout boxes extensively. The students perceived the problem solving required to complete a breakout box challenge as inherently creative. Students also regarded using online quiz builders (including Kahoot, Nearpod, Quizlet, and Quizizz) as academic creativity. Teachers discussed creating rubrics, formulating opinions, and participating in case studies and imagined scenarios as academic creativity. While there was no student-teacher crossover in these specific areas, all discussion around these tasks incorporated school device use, suggesting the importance of school devices in developing academic creativity.

Students discussed the second area of creativity, artistic creativity, more extensively than teachers, probably because students' focus in this section of the interviews was on the many ways that they see their classmates use the devices for non-class related purposes. Students at WMHS and GLSHS in particular noted that some classmates used school devices during class to sketch, "make nice artwork," compose music, draw, design 3D spaces, and create visuals and animation. Teachers also acknowledged the potential role that school devices can play in aesthetic pursuits related to content. Ms. Bee noted that "The device gives [students] a lot of options and they don't have to be good in art to be creative,' and went on to describe beautiful Power Point presentations that students had created for ELA presentations. Unlike students' descriptions of artistic creativity, which were unrelated to content, teachers generally connected creativity and content in their interviews.

The third area of creativity, technical creativity, was only touched upon briefly by teachers but was discussed extensively by GLSHS students and suggested by WMHS students. Programming, coding, creating hacks and workarounds for operating and security systems, and creating websites and wikis all emerged as areas of technical creativity. Although the schools in the current study did not directly address technical creativity through non-elective coursework, students indicated that teachers and administrators inadvertently encouraged this type of creativity. Mr. Zee at RVA acknowledged that restrictions placed on school devices were easy to get around but did not elaborate on students' approaches to those restrictions. Students at RVA, however, perceived that the school promoted technical creativity by restricting access to online gaming, certain videos, and shopping.

> Sue: I mean it's the undeniable truth. If they try to place like-
>
> Meera: Restrictions-
>
> Sue: Restrictions on us, people are going to find a way to use a computer, technology for non-academic purposes…it's like [that information] gets around.

Students indicated finding creative approaches to accessing the online information they wanted. Similarly, Alfonso at GLSHS noted, "like you run into a problem [with access through the Chromebooks] and you're like 'Hey by the way this happened' and then the next day you come in and [students] are like 'Do this' and then you're like 'Boom. Done.'" Students indicated embracing the challenge presented by restrictions and creatively solving problems related to accessibility.

Sam agreed with Alfonso, adding that students' level of boredom contributes to creative expression.

> Sam: There's all of these creative shortcuts and all these little tips and tricks that you can learn to do with your Chromebook, and that's the whole point. Even if they put restrictions on things in your way…if [students] are bored enough sitting in class, they're going to find a way to get around it.

As students had done at RVA, Sam at GLSHS also articulated the relationship between developing technical creativity and restrictions.

> Well I think that the thing that a lot of administrators overlook is they get so mad when kids do these kinds of things. They get around your restrictions and those kinds of things but at the same time it's also a good thing because the kids are learning to expand on different skills even if they're not the skills that they're trying to teach.

Building skills in technical creativity, while not a part of formal instruction in one-to-one high schools, emerged as a possible common feature of one-to-one initiative programs in high schools. Given the need for individuals skilled in cyber security, skills related to technical creativity would seem valuable for schools to continue to develop.

The essence of creativity. When asked directly about creativity in one-to-one initiatives, students had little to say, and their perceptions seemed limited. Teachers similarly expressed opinions that academic requirements left limited room for creative expression in one-to-one high schools. Both groups of participants, however, spoke extensively about creative solutions to challenges encountered in school, and themes around creativity emerged, with participants relating it to academic, artistic, and technical endeavors. Traditional notions of creativity as limited to visual and fine arts may limit what appears to be an expanding understanding of creativity's relationship to innovation.

Digital Literacy

The P21 Framework (Battelle for Kids, 2019b) defines digital literacy as the abilities people must possess to function and think critically in relation to information, media, and technology. Information literacy involves the ability to efficiently and effectively access, evaluate, organize, and use information from a variety of sources. Media literacy is the ability to understand the motivations behind media messages based on an examination of how people interpret media messages and how media can influence people's beliefs and behavior. Understanding and using media creation tools is also part of this area of literacy. Information, communications, and technology (ICT) literacy reflects the ability to use technology as a research tool and includes organizing, evaluating, and communicating information. In addition, ICT literacy includes using devices as well as social media appropriately to "access, manage, integrate, evaluate and create information to successfully function in a knowledge economy" (p. 5). Each of these areas also points to the importance of developing ethical understandings.

In this area of inquiry, terminology proved to be a sticky point for participants as well as the individuals who initially offered feedback on the created interview protocol. Within the original conceptualization of this study and the interview protocol, the researcher explored using the terms "ICT literacy" or "information, media, and technology literacy." Feedback from pilot groups, however, identified these terms as being unintelligible or confusing to high schoolers; thus, in the interview the term "digital literacy" was used. Throughout this discussion of results, the term "digital literacy" will be used to encompass the terms "media, technology, and information literacy."

What is digital literacy? Most student focus groups (n = 5) and one teacher expressed not knowing how to define the term "digital literacy," and students' initial, halting definitions of digital literacy explicated the skill as analogous to paper-based literacy. Students in one WMHS focus group asked, "Is that like writing? Writing on your computer?" A student at GLSHS speculated that the definition of digital literacy might be "Literacy on a digital device...like reading on your computer." One RVA teacher initially stated that he was unsure how to interpret digital literacy. Despite their initial hesitancy, all teachers and students contributed at least limited explanations of digital literacy.

Teachers settled on definitions that largely focused on critical thinking, research-related skills, and the ability to maneuver competently in information-rich contexts, while students focused more often on abilities to physically use digital devices, software, and online resources effectively, efficiently, and judiciously. Six of seven teachers and three focus groups also mentioned negotiating the media as an aspect of digital literacy.

In discussions of digital literacy, teachers often focused on an odd relationship between teenagers' seeming ability to do anything on their personal devices while possessing an inability to generalize those skills to computer use for academic purposes. Ms. Em observed that "students know many things to do with computers," and that sentiment was echoed by Ms. Gee, who stated, "if they want to do anything on their iPads they know what to do." Ms. Gee went on to add, however, that "it's kind of funny how that doesn't transfer to the [graphing] calculators." The researcher also noted this lack of transferability during a statistics class observation. Teachers perceived that students' digital know-how was limited largely to social media use and physical control of their devices, which was not discussed in relation to digital literacy but instead in relation to device use—an important distinction made by all but one teacher.

From teachers' perspectives, digital literacy incorporated using keywords effectively to find useful websites ($n = 4$), assessing information to determine its reliability ($n = 5$), filtering information and subsequently dealing with questionable content ($n = 4$), and effectively negotiating media sources ($n = 2$). Mr. Jay further developed this definition by adding abilities associated with manipulating documents, describing using Word, Google Docs, and Dropbox to create, upload, download, rename, and save documents as abilities associated with digital literacy.

Like teachers, when asked to define digital literacy, students described knowing how to use computers and personal devices. When asked how they had developed that knowledge, student at RVA stated, “We have had access to technology since we were little so we are familiar with what to do.” One WMHS student noted “Students just know how to figure things out” while another pointed out, “Having earlier access to Apple devices has helped us understand software.” Students’ responses suggest that they may regard digital literacy as related to physically manipulating their devices. Additionally, students may view digital literacy as intuitive rather than a skill to be developed.

Students in five focus groups discussed digital literacy’s relationship with learning how to do research; however, they did not expand on this relationship beyond the recognition that they might “use technology successfully for research” (GLSHS). In explaining their understanding of digital literacy, students spoke most extensively of operating a device successfully (n = 3), communicating through technology (n = 2), and typing (n = 3).

How schools promote digital literacy. Because teachers and students expressed different understandings of digital literacy, they also described different avenues by which digital literacy is promoted. In describing how they support students’ digital literacy development, five teachers explained how they train students to search for information and justify the validity of found information. In this four-step approach, teachers stimulate inquiry, and then facilitate the execution of online research, source evaluation, and communicating findings (Figure 7).

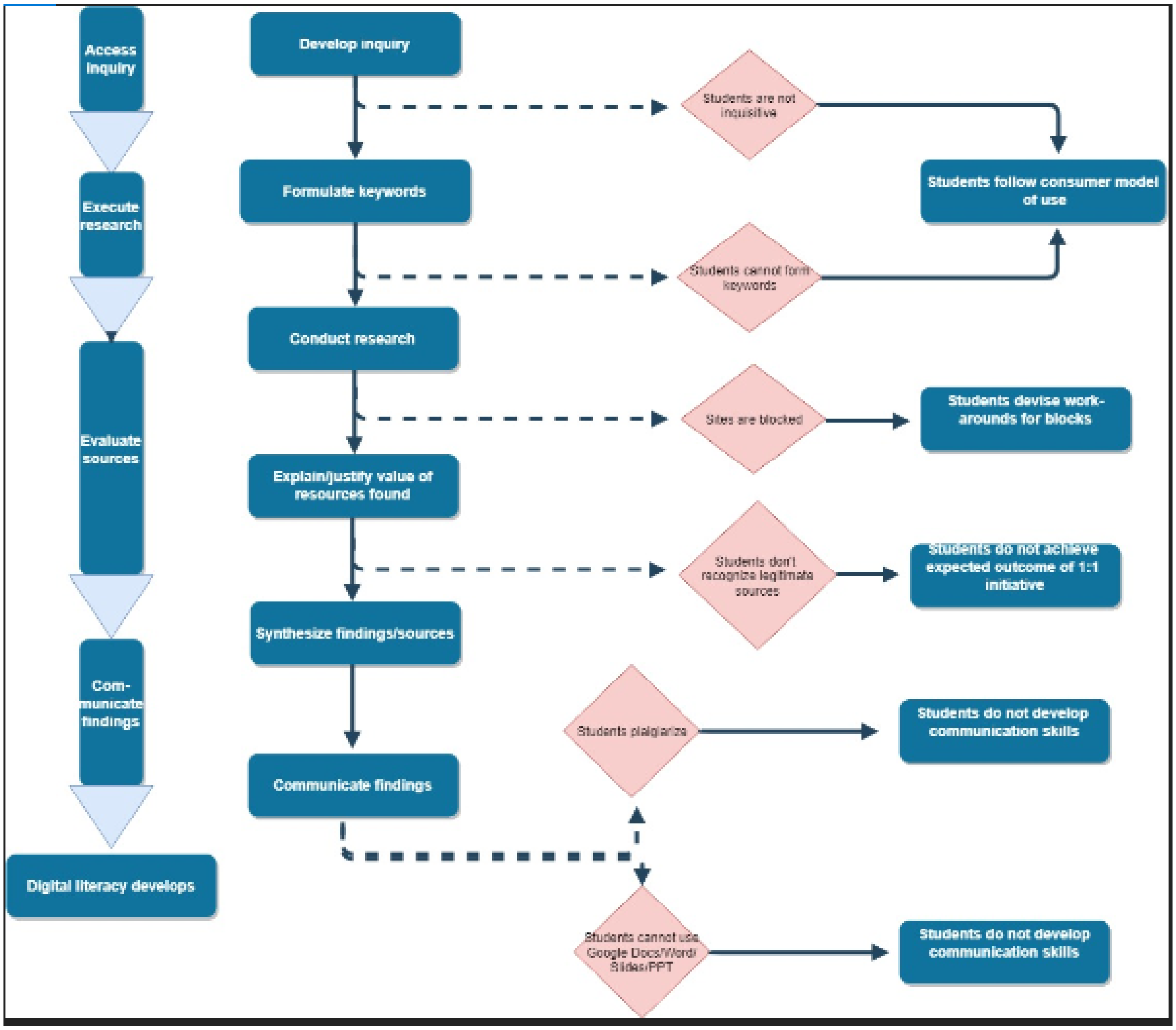

Figure 7. Teachers' described process of digital literacy development.

At each of those four steps (represented by arrows in Figure 7), teachers have an expected outcome for students: developing inquiry, formulating keywords, independently carrying out research, justifying the value of resources found, synthesizing findings, and communicating findings. Descending rectangles (between the arrows and diamonds) show the flow of abilities that students must possess to competently carry out research. At each of those stages, teachers must support students in steering away from pitfalls (represented by diamonds in Figure 7). Pink diamonds represent the pitfalls students may encounter during the research process and rectangles to the right describe outcomes if those pitfalls go unaddressed and students fail to develop skills within the 21st century skill set.

In a GLSHS civics class, for example, the teacher and students discussed whether burning the American flag is protected speech under the First Amendment (stimulating inquiry) and gave the students three minutes to develop a position based on online research (facilitate online research). When one student discovered the 1990 case of *United States v. Eichman* that invalidated a federal law against flag desecration as violating free speech under the First Amendment, the teacher asked the student his source (source evaluation) and then asked him to describe the case (communicating findings). The teacher then gave additional feedback on the student's research success by excitedly asking the student to send him a link to the case and complimenting the student on his thorough research skills. In a different class with the same teacher, when students were given the same question, the teacher guided the students away from giving uninformed opinions and reminded them to find authoritative sources.

T; Did anyone look it up? Whether burning the American flag is protected speech?

S1; [pointing to Chromebook screen] Yeah, it's not protected, it says it in the little box.

T; What's the little box's source?

S1; Dunno, it's the little box.

T; The little box is not an authoritative source, ok? You need to find authoritative sources.

Teachers gave students feedback on online research skills and information assessment in both GLSHS classrooms, but not in the other four classrooms observed. This observation may be due to the fact that GLSHS teachers have undergone extensive training through Google's Teacher Academy while professional development at the other two schools was described in interviews as being more limited or narrower in focus (e.g., devoted to mastering the use of an app or online tool). A definitive cause is unknown given the qualitative nature of this portion of the study.

Three teachers described achieving digital literacy through a focus on subject matter-related tasks such as working with mathematical proofs and finding and sharing current events. Ms. Bee, in contrast, described devoting considerable time to just teaching students how to deal with online information. She explained

> Every time we have something where I send them out [onto the Internet], there's always that conversation ahead of time. Now what kind of sites are we looking for? What's a legitimate source?...And I've given them some questions to ask themselves, a checklist kind of moving them in that direction. We spent some time at the beginning of the year with [the school librarian] and talked about databases and primary sources and how you can sort of search for those things…That's one thing that I'd really like them at the end of the year to leave with—that skill that, if I'm looking for academic information where do I find it and how do I prove that it's a worthwhile source.

These two teachers indicated employing direct and indirect approaches to building students' digital literacy, helping students learn to deal with information through studied content as well as through more direct, explicit, skill-building approaches.

Classroom observations supported teachers' uses of direct approaches to teach students to be more digitally literate. In all observed classrooms, teachers provided students with pre-selected resources and/or topics, supporting the materials' presentation with technology. In the three WMHS classrooms, teachers directed students on how to use the provided resources (for example, by instructing students to highlight or annotate certain sections of a studied document). In the RVA and GLSHS classrooms, students were guided to use the provided resources to design search parameters and independently search for and choose appropriate materials to support learning.

Only one teacher, Mr. Jay, discussed digital literacy in terms of using programs or platforms. He described digital literacy as “kids learning how to work with a Google Doc [and] Dropbox.” He also noted unequal digital literacy within his classes between students taking AP physics classes and those studying conceptual physics, a non-tested class.

> My conceptual physics class…had to be taught how if you pull up a Google Doc how you can enter work in it [when] collaborating with teammates. And they…had to be taught how to go to File, download the Doc, change the name, and then take it and put it on the discussion board. These are things where I tried my AP class I didn’t have to tell them anything. Conceptual [physics] and College Prep both needed to know this and you and I would think these would be the basics but it was new to them; however, once I showed it to them…they picked it up really fast but they didn't know it to begin with, as if the laptop was not used [before now].

Mr. Jay’s comment suggests that one-to-one initiative devices, at least in his context, are not used consistently between classrooms or tracks, and that content mastery may take precedence over skill building or digital literacy development, especially with low-achieving or non-college bound students. In addition, students involved in one-to-one initiatives may not, despite ubiquitous access to a device, be encouraged to build the digital literacy that will allow them to become creators within and contributors to the digital world. If this situation is true across schools, then one-to-one initiatives are falling short of equitable content delivery and skill building.

While teachers mostly focused their definitions of digital literacy on research, students focused on abilities to manipulate the device which, all focus groups pointed out, is an area in which students do not need teaching. When describing how digital literacy is supported in one-to-one initiative high schools, three themes emerged in focus group discussions. The first and most frequent theme involved learning through experimentation and experience. Although students in all three high schools had taken or had the opportunity to take computer classes during their secondary schooling, they did not connect those classes with digital literacy. Instead, they explained developing their digital literacy, skills, and knowledge through experimentation. Students at all three high schools cited "trial and error," "just figuring things out," and "exploring the Internet" as the avenues by which they develop digital literacy. The second theme that emerged around digital literacy development involved the input of a significant other, such as a parent or peer.

Three focus groups pointed out that students have higher technical abilities than teachers, and their knowledge of how to operate computers and other digital devices "turns the tables" on the traditional classroom power structure in which the teacher controls the learning. Interestingly, one GLSHS focus group noted that they would appreciate teachers delivering direct instruction on Google Classroom so that they might maximize its use in their studies. One student remarked, "Teachers wrongly assume that students have an ability to do certain things on their computers [but] students learn how to use technology effectively in part from teachers." However, no other groups expressed this position.

The essence of digital literacy. Despite initial confusion about the nature of digital literacy, all student groups and teachers spoke at length about digital literacy. Students' focus on physically using the devices suggested a surface understanding of the power of the devices they interact with daily as well as limited interactions with the world of information available through the Internet. Teachers' definitions conveyed a stronger understanding of digital literacy and also communicated their understanding that the digital environment is one that truly requires a different understanding of literacy to navigate successfully. Fortunately, teachers expressed awareness of students' limited digital literacy, and six of seven participants were able to express in depth a four-step approach to teaching students to deal with online information. Their descriptions also conveyed an understanding of the ramifications of students not developing an ability to function competently in the online world. One teacher noted unequal digital abilities between low- and high-achieving students, suggesting that a digital divide may exist within one-to-one initiative schools even when all students have ubiquitous access to Internet-connected devices.

Summary

In answer to the question, "What 21st century skill development is identified by students and teachers in an activity system in which one-to-one devices are the mediating artifact?" discussions settled only on the skills suggested by the researcher—collaboration, communication, creativity, and digital literacy. Teachers and students suggested a strong relationship between their school devices and approaches to content mastery and critical thinking. In addition, participants discussed general skills being promoted within their high schools, but none aligned significantly with the P21 Framework. Analysis of data revealed differences of perceptions between teachers and students as to the meaning of the skills as well as their importance.

Students' perceptions of 21st century skills frequently focused on the relationships between communication and collaboration and digital devices. In addition, students perceived these skills as mostly unsupported by in-school approaches but highly utilized outside of the school setting through a combination of school and personal devices. Students perceived that they developed communication and collaboration skills through trial and error within school assignments. Feedback on this skill development came through experiences with peers while teachers gave feedback on content mastery as executed through school devices. Students indicated that high school afforded few opportunities for creativity; however, they also discussed participating in varied and creative learning approaches in classes. It is possible that, because students often defined creativity in terms of fine and visual arts, they did not recognize the creativity that surrounds them in school. Finally, students regarded themselves as digitally literate due to perceived abilities in using their school and personal devices, and they remarked that their school devices gave them a leg up in skills related to digital literacy. This restricted definition suggests their limited understanding of digital literacy and its relationship to online information management.

Conclusion

Teachers interviewed overwhelmingly insisted that supporting 21st century skill development is essential, especially given the importance of those skills in the workforce. However, they were careful to add that knowledge also has a very definite place in the high school classroom. Teachers' perceptions of 21st century skills frequently focused on the relationship between collaboration, communication, creativity, digital literacy, and content mastery while noting that standardized testing and curricular requirements limit their abilities to develop skills, especially creativity. Teachers named many ways that they support 21st century skill development, but not all of them incorporated school devices and few skill-building activities were undertaken consistently, especially in courses aligned to standardized testing requirements. In fact, most teachers acknowledged not having students use school devices everyday due to their potential to distract students or disrupt their ability to retain content. Teachers were almost universally clear in their approaches to developing students' digital literacy, describing a four-step process to teaching students to deal with online information. For teachers, however, simply using the digital device was not part of their definition of digital literacy.

The analyses in chapter four led to a proposed instrument for measuring 21st century skill development, which was consequently subjected to tests of validity and reliability. Quantitative data determined the extent to which the findings generated from the qualitative phase of the study confirmed perspectives of 21st century skill development in one-to-one initiative high schools. The results of the validity and reliability testing appear in chapter five and a discussion of findings follows in chapter six.

CHAPTER FIVE

QUANTITATIVE FINDINGS

The aim of the current study was to create an instrument to measure perceptions of 21st century skill development among high school students involved in one-to-one initiatives. Chapter four reported the qualitative findings related to observations and interviews with students and teachers in three different one-to-one initiative high schools. The qualitative findings of that chapter resulted in items which may reflect 21st century skill development in one-to-one initiative high schools. This chapter details the results of a three-step process to determine items' reliability, validity, and adequacy in order to answer research question three: "What items in a 21st century skill-measuring instrument represent the results of the qualitative phase of the study?" The first step involved 12 subject matter experts (SMEs) who rated the items on clarity while the second step involved 53 individuals who gave feedback on the extent to which items reflected domains of the 21st century skill set. The final step involved analyses and subsequent elimination and modification of items to arrive at an instrument ready for pilot testing. The current chapter will focus on quantitative findings related to instrument development.

Overview

In total, the qualitative analyses yielded 57 proposed items within six domains (i.e., communication, collaboration, creativity, digital literacy, content mastery, and expanded thinking). In the first step of quantitative analyses, SMEs who had authored published studies addressing educational technology and/or 21st century skills, taught classes that included technological elements or addressed 21st century skills, or administrated programs with technology elements or 21st century skill statements assessed the proposed items. Of the 15 SMEs approached, 12 completed the survey. In the second step, a group of 53 undergraduate students evaluated the remaining items and identified the domains (factors) under which each item belonged.

To analyze the resultant data in step one, the researcher calculated a mean numerical rating (MNR), item content validity index (I-CVI), and a modified kappa (MK) coefficient for each item to determine whether the item should remain and receive further consideration for inclusion in the instrument. In step two, the researcher calculated analysis of variance (ANOVA) to detect significant differences between mean scores for each item. Q-correlations reflected the extent to which means correlated and facilitated an exploratory factor analysis (EFA) to determine item loadings. The final instrument contains 31 items within six domains.

Sample

While all respondents in step one had had experience teaching in classrooms with technological elements, two also had acted as administrators in districts with educational technology, and two had authored published studies addressing educational technology. The professional experiences of the SMEs in relation to classroom technology appear in Table 14.

Table 14

Subject Matter Experts' Experiences With Technology

Qualifications	**N (%)**
Experience teaching in classrooms with technological elements	12 (100%)
Administrative experience in a school or district that includes technological elements	2 (17%)
Authored published studies addressing educational technology	2 (17%)

All respondents had worked with classroom technology for at least one year, but most (n = 9) had more than five years of experience in schools with technological elements (Figure 8).

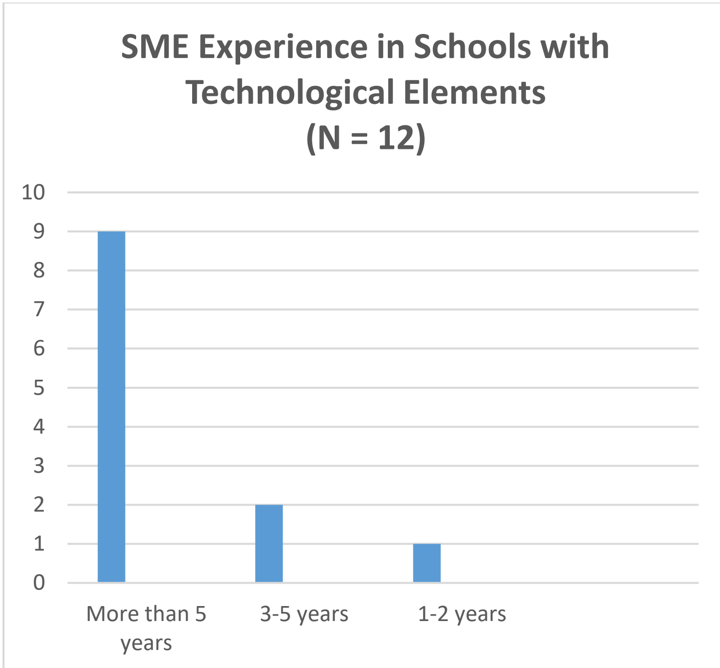

Figure 8. Subject matter experts' length of experience in schools with technological elements.

SMEs also indicated a variety of experiences with different types of classroom technology. All respondents indicated having taught in technology-rich educational environments but with differing levels of available technology. Almost all (n = 11) had had experience teaching in a school or institution with computers available in centralized locations, like computer labs. Most SMEs (n = 9) also had experience with bring your own device (BYOD) programs. An equal number had experience working in a cart model. Half of the SMEs indicated having experienced a one-to-one initiative. One individual had worked with a Self-Organized Learning Environment (SOLE), which is designed to leverage computers in the classroom to support self-directed education for young learners. Another respondent had experience in a Library Learning Commons as Maker Space. This type of space often contains tools, machinery, and technologies associated with "making" such as three-dimensional (3D) printers, laser cutters, robotics, and vocational tech machinery (Table 15).

Table 15

Programs, Initiatives, and Environments Subject Matter Experts (SMEs) Experienced

Technological Elements Identified	N (%)
Computers available in centralized locations (like computer labs)	11 (92%)
Bring your own device (BYOD)	9 (82%)
Cart model	9 (82%)
One-to-one initiative	6 (55%)
Library Learning Commons with Maker Space	1 (9%)
Self-Organized Learning Environment (SOLE)	1 (9%)

SMEs also indicated their previous experiences with 21st century skills-supporting programs or environments. In total, 11 respondents indicated having worked in a 21st century skills-supporting environment. Most SMEs (n = 7) had experience spanning more than five years, while two had between three and five years of experience and two had one to two years of experience (Figure 9).

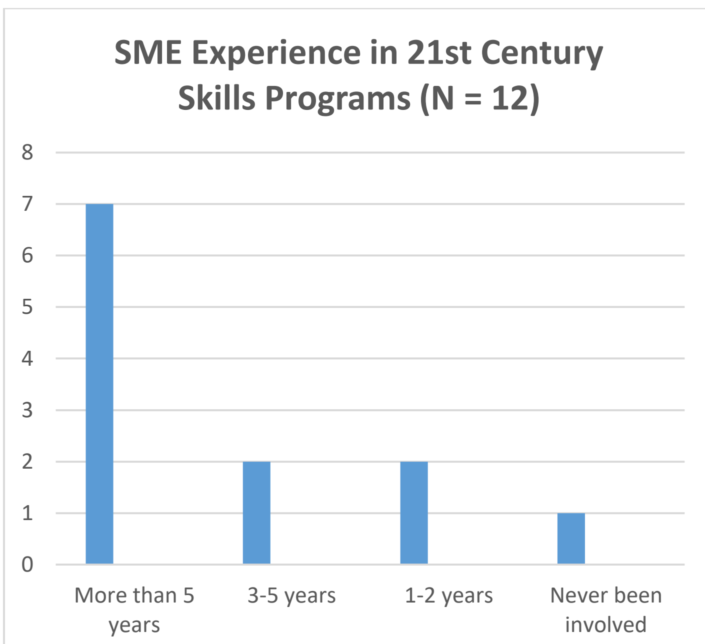

Figure 9. Subject matter experts' length of experience in 21st century skills programs.

The researcher recruited the phase two step two participants from a group of undergraduates attending an education program in the northeastern United States. As noted by Hinkin *et al*. (1999), such a sample meets the requirements of item evaluation as they were literate and able to comprehend the task at hand.

Findings: Research Question Three

The findings below are presented to reflect the two phases of item assessment. Therefore, potential items for inclusion in the final instrument are described using both their step one and step two identifiers (e.g., COMM5/Item 13). Each item's step one mean MNR, I-CVI, and MK are reported initially according to MNR scores (highest to lowest). Included items' step two ANOVA and post hoc results are then detailed, as are the results of the EFA, which was run to suggest item rewording and potential factor loadings for each item. Step one results are followed by statements of elimination or retention.

Collaboration Domain

During the qualitative phase of research, nine common items emerged as indicators of high collaboration abilities in one-to-one initiative high schools (Table 15): working together with classmates on school assignments using a school device (COLL1), working through conflict within groups of classmates (COLL2), persuading others of an opinion when working within a digital environment (COLL3), compromising with others in a digital environment (COLL4), working with classmates in digital platforms to master content (COLL5), using online platforms to arrange and carry out collaborative tasks (COLL6), using a school device to work together with classmates on graded assignments (COLL7) or with classmates on extracurricular projects/assignments (COLL8) and finding consensus (COLL9). SMEs determined that all items were clearly worded, except for COLL3, COLL4, COLL7, and COLL8.

Table 16

Collaboration Domain Item Scores

No.	Item	Strong (n)	Mod (n)	Weak (n)	Mean	MK	I-CVI	Clear (n)	Unclear (n)	Step 1 Action	Survey No.
COLL1	Working together with classmates on school assignments using a school device.	7	5	0	7.92	NC	.167	11	1	Eliminate	N/A
COLL2	Working through conflict within groups of classmates.	8	4	0	8.33	.33	.33	11	1	Include (reword)	17
COLL3	Persuading others of an opinion when working within a digital environment.	5	7	0	6.83	NC	-.167	10	2	Eliminate	N/A
COLL4	Compromising with others in a digital environment.	7	5	0	7.17	NC	.167	8	4	Eliminate	N/A
COLL5	Working with classmates in digital platforms to master content.	9	3	0	7.75	.50	.50	11	1	Include	N/A
COLL6	Using online platforms to arrange and carry out collaborative tasks.	9	3	0	8.58	.50	.50	12	0	Include	26
COLL7	Using a school device to work together with classmates on graded assignments.	9	3	0	8.08	.50	.50	11	1	Eliminate (redundant)	23
COLL8	Using a school device to work together with classmates on extracurricular projects/assignments	8	4	0	7.75	.33	.33	10	2	Include (reword)	27
COLL9	Finding consensus	9	3	0	8.09	.50	.50	11	1	Include	9

Note. MK: modified kappa; I-CVI: item content validity index; No.: number; N/A: not applicable; NC: not calculated

COLL1, COLL3, COLL4, and COLL7 were eliminated, but COLL8 was reworded and retained despite a low I-CVI (.33) and MK (.333) due to its relatively high MNR (8.33). Collaboration's S-CVI/Ave was unacceptably low (.5), suggesting the low validity of the scale for this factor and the possibility that this 21st century skill domain may not truly be supported in high school one-to-one initiatives. However, potential collaboration items were included in step two for further analyses because collaboration is consistently included in 21st century skill models.

COLL6/Item 26 (*Using online platforms to arrange and carry out collaborative tasks*) had the highest numerical rating within the current domain, but only a barely acceptable I-CVI and MK (MNR = 8.58; I-CVI = .5; MK = .5). The item was reworded for step two (*Arranging and carrying out tasks that require group* work). The ANOVA revealed a significant difference of means within the item, $F(5, 312) = 7.652$, $P = 0.000$, and a Games-Howell post hoc test showed significantly higher perceptions of the item expressing collaboration ($M = 4.40$, $SD = .793$) versus critical thinking ($M = 3.60$, $SD = 1.115$, $P = 0.001$), digital literacy ($M = 3.15$, $SD = 1.321$, $P = 0.000$), creativity ($M = 3.72$, $SD = 1.133$, $P = 0.007$), and content mastery ($M = 3.68$, $SD = 1.221$, $P = 0.007$). These findings suggest that this item strongly and uniquely portrays collaboration in one-to-one initiative high schools. However, in a preliminary EFA, this item loaded strongly on content mastery (.759, variance = 9.87%, eigen = 3.356). These contradictory findings suggest the need for further analyses. The item's wording was simplified in response to this finding (Appendix H).

COLL2/Item 17 (*Working through conflict within groups of classmates*) had a high MNR (8.33), but both the I-CVI (.33) and MK (.33) were low, suggesting low validity of the item. Further analyses revealed a significant difference of means within the item, $F(5, 312) = 14.639$, $P = 0.000$, and a Games-Howell post hoc test showed a significantly higher perception of the item expressing collaboration (*M* = 4.28; *SD* = .948) versus digital literacy (*M* = 3.04; *SD* = 1.143, *P* = 0.000), creativity (*M* = 3.15; *SD* = 1.215; *P* = 0.000), and content mastery (*M* = 3.32; *SD* = 1.283, *P* = 0.000). These findings suggest that this item may uniquely express collaboration in a one-to-one initiative high school. However, a preliminary EFA found that this item failed to load under any factors, supporting the low validity in step one and suggesting that this qualitative finding may not be supported at a population level and therefore not warrant inclusion in an instrument designed to measure 21st century skills. Pilot testing with a larger sample will possibly yield more conclusive results on this item's inclusion, but the researcher chose to maintain the item for pilot testing due to its possibility to represent collaboration.

Like previous items in this domain, COLL7/Item 23 (*Using a school device to work together with classmates on graded assignments*) had relatively low validity and reliability (MNR = 8.08; I-CVI = .5; MK = .5). Further analyses revealed a significant difference of means within the item, *F*(5, 312) = 9.214, *P* = 0.000, and a Games-Howell post hoc test showed a significant higher perception of the item expressing collaboration (*M* = 4.53, *SD* = .608) versus critical thinking (*M* = 3.66; *SD* = 1.126; *P* = 0.000), digital literacy (*M* = 3.55; *SD* = 1.186; *P* = 0.000), creativity (*M* = 3.77; *SD* = 1.120; *P* = 0.001), and content mastery (*M* = 3.55; *SD* = 1.119; *P* = 0.000). In the preliminary EFA, this item loaded strongly under digital literacy with no cross loadings (.790, variance = 20.37%, eigen = 6.926). Preliminary EFA results suggest that this item may more appropriately reflect digital literacy, although the lack of significant difference between perceptions of collaboration and communication (*M* = 4.36; *SD* = .922; *P* = 0.872) suggests that this item would benefit from rewording and an EFA with a larger sample. The item was simplified in anticipation of pilot testing (*Working together with classmates [in face-to-face and digital environments] on graded assignments*).

COLL9/Item 9 (*Finding consensus*) had low validity but an acceptable MNR and reliability (MNR = 8.09; I-CVI = .27; MK = .5). Further analyses revealed a significant difference of means within the item, $F(5, 312) = 3.562$, $P = 0.004$, and a Games-Howell post hoc test showed a significant difference between perceptions of the item expressing collaboration ($M = 3.77$; $SD = 1.068$) and creativity ($M = 3.47$; $SD = 1.339$; $P = 0.005$). Respondents also indicated a higher mean perception of this item reflecting collaboration than other domains with the exception of communication, although none of these findings were significant. This item failed to load under any factor during EFA, suggesting that it may not reflect collaboration at a population level. Due to its failure to load on one factor and its overall low ratings of validity and reliability, the researcher chose to eliminate this item.

COLL8/Item 27 (*Using a school device to work together with classmates on extracurricular projects/assignments*), like other items in this domain, was determined to have relatively low validity (MNR = 7.75; I-CVI = .33; MK = .33). Further analyses revealed a significant difference of means within the item, $F(5, 312) = 10.489$, $P = 0.000$, and a Games-Howell post hoc test showed a significantly higher perception of the item expressing collaboration ($M = 4.49$; $SD = .639$) versus critical thinking ($M = 3.77$; $SD = 1.050$; $P = 0.001$), digital literacy ($M = 3.60$; $SD = 1.246$; $P = 0.000$), creativity ($M = 3.77$; $SD = 1.077$; $P = 0.000$), and content mastery ($M = 3.45$; $SD = 1.234$; $P = 0.000$). Preliminary EFA found that this item loaded moderately strongly with no cross loadings under digital literacy (.734, variance = 6.14%, eigen = 2.086), suggesting the possibility that this item expresses digital literacy rather than collaboration. Due to similarities between this item and item 23, the researcher merged the two in anticipation of pilot testing with a larger sample. All factor loadings and their cross loadings in the collaboration domain appear in Table 17.

Table 17

Factor Loadings in the Collaboration Domain and Their Cross Loadings

					CROSSLOADINGS				
No.	**Description**	**Collab**	**Var (%)**	**Eigen**	**Comm**	**Crit Think**	**Creat**	**Cont Mast**	**Dig Lit**
18	Using information or digital technologies to understand school-related material better.	.914	39	13.262		.774			
30	Being able to find websites to make classroom content more meaningful.	.889	4.8	1.630		.690	.773		
28	Using online resources to carry out research.	.877	4.28	1.456		.721			
11	Independently assessing information for reliability.	.876	3.42	1.226	.868	.721			
34	Finding websites that help make studied content more understandable.	.869	2.69	1.162			.777	.712	

Note. Collab: collaboration; Var: variance; Eigen: eigenvalue; Comm: communication; Crit Think: critical thinking; Creat: creativity; Cont Mast: content mastery; Dig Lit: digital literacy

Communication Domain

During the qualitative phase of research, eight common items emerged as indicators of communication abilities in one-to-one initiative high schools: using a school device to give feedback to peers on school assignments (COMM1), receiving feedback from peers (COMM2) or teachers on school assignments (COMM3), contacting teachers outside of school hours (COMM4), problem solving based on research findings (COMM5), asking questions outside of class through email or discussion boards (COMM6), contacting others in planning extracurricular activities (COMM7), and discussing research findings (face-to-face and through digital platforms) with teachers and other students (COMM8) (Table 18).

Table 18

Communication Domain Item Scores

Number	Item	Strong (n)	Mod (n)	Weak (n)	Mean	Kappa	I-CVI	Clear (n)	Unclear (n)	Step 1 Action	Survey No.
COMM1	Using a school device to give feedback to peers on school assignments.	10	2	0	8.25	.67	.667	11	1	Include (reword)	32
COMM2	Using a school device to receive feedback from peers on school assignments.	9	3	0	7.58	.50	.5	10	2	Include (reword)	4
COMM3	Using a school device to receive feedback from teachers.	7	4	1	7.42	NC	.167	11	1	Eliminate	N/A
COMM4	Using a school device to contact teachers outside of school hours.	11	1	0	8.5	.83	.833	11	1	Include	25
COMM5	Using a school device to problem solve based on research findings.	11	1	0	8.72	.84	.833	10	2	Include (reword)	13
COMM6	Using a school device to ask questions outside of class through email or discussion boards.	11	1	0	8.58	.83	.833	11	1	Include	7
COMM7	Using a school device to contact others in planning extracurricular activities.	9	3	0	8.08	.50	.5	11	1	Include	8
COMM8	Discussing research findings (face-to-face and through digital platforms) with teachers and other students	11	1	0	8.73	.83	.66	12	0	Include	6

Note. MK: modified kappa; I-CVI: item content validity index; No.: number; N/A: not applicable; NC: not calculated

Most SMEs (n = 11) determined that items were clearly worded except for COMM2 and COMM5, so both were reworded for step two. COMM3 had the lowest numerical rating within the current domain (MNR = 7.42) and a very low I-CVI (.167) so was eliminated in step one, and the MK was not calculated.

SMEs indicated that COMM5/Item 13 (*Using a school device to problem solve based on research findings*) had high validity and reliability (MNR = 8.72; I-CVI = .66; MK = .84). The ANOVA revealed a significant difference in means within the item, $F(5, 312) = 6.917$, $P = 0.000$, and a Games-Howell post hoc test showed a significant difference between perceptions of the item expressing communication ($M = 4.11$, $SD = .934$) versus digital literacy ($M = 3.43$, $SD = .855$; $P = 0.015$) and creativity ($M = 3.49$, $SD = 1.187$; $P = 0.039$). However, EFA (Table 18) showed that the item loaded under the digital literacy domain (.643, variance: 3%, eigen: 1.020) without cross loadings. This finding suggests that the item would potentially load under digital literacy upon EFA conducted with a larger sample. The item's wording was simplified to "*Discuss approaches to problem* solving," for pilot testing.

COMM8/Item 6 (*Discussing research findings [face-to-face and through digital platforms] with teachers and other students*) was rated highly in step one of phase two (MNR = 8.72; I-CVI = .833; MK = .84). The ANOVA revealed a significant difference in means within the item, $F(5, 312) = 7.043$, $P = 0.000$. The mean perception of the item representing communication was higher as compared to all other domains, and a Games-Howell post hoc test showed a significantly higher mean of the item expressing communication ($M = 4.40$, $SD = .947$) versus digital literacy ($M = 3.77$, $SD = 1.154$, $P = 0.035$), creativity ($M = 3.45$, $SD = 1.280$, $P = 0.001$), and content mastery ($M = 3.64$, $SD = 1.111$, $P = 0.004$). A preliminary EFA showed that the item loaded under the digital literacy domain (.717, variance: 4.27%, eigen: 1.452) without cross loadings. In response, the researcher simplified this item's wording (*Discussing research with teachers and other* students). Pilot testing with a larger sample will clarify the item's domain.

COMM6/Item 7 (*Using a school device to ask questions outside of class through email or discussion boards)* was also determined to have excellent validity and reliability (MNR = 8.58; I-CVI = .833; MK = .83). The ANOVA revealed a significant difference in means within the item, $F(5, 312) = 6.812$, $P = 0.000$), and a Games-Howell post hoc test showed a significantly higher mean between perceptions of the item expressing communication ($M = 4.40$, $SD = .793$) versus digital literacy ($M = 3.81$, $SD = 1.161$; $P = 0.036$). A preliminary EFA showed that the item loaded under the digital literacy domain (.749, variance: 7%, eigen: 2.378) with a cross loading on content mastery. The researcher simplified the item's wording (*Participating in online discussion boards*) to address cross loadings in pilot testing, eliminating the reference to email to simplify the item.

COMM4/Item 25 (*Using a school device to contact teachers outside of school hours*) was the third item in the communication domain that displayed high levels of validity and reliability (MNR = 8.5; I-CVI = .833; MK = .83) in the first step of phase two. The ANOVA revealed a significant difference in means within the item, $F(5, 312) = 5.832$, $P =0.000$, and a Games-Howell post hoc test showed a significant difference between perceptions of the item expressing communication ($M = 4.19$, $SD = .921$) versus critical thinking ($M = 3.49$, $SD = 1.353$, $P = 0.03$), creativity ($M = 3.43$, $SD = 1.217$, $P = 0.007$), and content mastery ($M = 3.43$, $SD = 1.352$, $P = 0.014$). A preliminary EFA showed that the item cross loaded under three other domains, so the researcher simplified the wording (*Emailing teachers*).

SMEs gave feedback during step two phase one that COMM2/Item 4 (*Using feedback* *from schoolmates [face-to-face and through digital platforms] on school assignments*) should be retained but reworded. The extremely low validity and reliability (MNR = 7.58; I-CVI = .50; MK = .50) suggested that the item did not represent communication clearly. The ANOVA revealed a significant difference in means within the item, $F(5, 312) = 11.924$, $P = 0.000$), and a Games-Howell post hoc test showed a significant difference between perceptions of the item expressing communication ($M = 4.38$, $SD = .860$) versus critical thinking ($M = 3.51$, $SD = 1.120$, $P = 0.000$), digital literacy ($M = 3.58$, $SD = 1.117$, $P = 0.001$), creativity ($M = 3.19$, $SD = 1.429$, $P = 0.000$), and content mastery ($M = 3.45$, $SD = 1.084$, $P = 0.000$). EFA showed that the item loaded strongly on creativity (.879, variance: 42.97%, eigen 14.611) despite the significantly higher ANOVA in communication. This unexpected result in combination with the results of step one suggest that this item may not be statistically reliable as it stands. Therefore, the researcher reworded the item in anticipation of pilot testing (*Using peer feedback to make improvements*).

COMM1/Item 32 (*Giving feedback to peers [face-to-face and through digital platforms] on school assignments*) showed acceptable validity and good reliability (MNR = 8.25; I-CVI = .67; MK = .67). The ANOVA revealed a significant difference of means within the item, $F(5, 312) = 9.444$, $P = 0.000$, and a Games-Howell post hoc test showed a significantly higher perception of the item expressing communication ($M = 4.38$, $SD = .790$) versus critical thinking ($M = 3.79$, $SD = .968$, $P = 0.012$), digital literacy ($M = 3.70$, $SD = 1.119$, $P = 0.006$), creativity ($M = 3.53$, $SD = 1.250$, $P = 0.001$), and content mastery ($M = 3.53$, $SD = .992$, $P = 0.000$). EFA showed that the item loaded strongly on digital literacy (.806, variance: 28.38%, eigen 9.650), with a cross loading on creativity, so the researcher reworded the item (*Giving peers feedback*) for peer feedback.

COMM7/Item 8 (*Planning extracurricular activities in conjunction with teachers and other students*), which replicated COLL8, had low but still acceptable validity and reliability (MNR = 8.08; I-CVI = .50; MK = .50). ANOVA revealed a significant difference in means within the item, $F(5, 312) = 5.896$, $P = 0.000$, and a Games-Howell post hoc test showed a significantly higher perception of this item expressing communication ($M = 4.13$, $SD = .962$) versus critical thinking ($M = 3.47$, $SD = 1.120$, $P = 0.019$) and content mastery ($M = 3.40$, $SD = 1.230$, $P = .011$). EFA showed that the item loaded on critical thinking without cross loadings, although the variance and eigen value were low (MNR = .659, variance = 3.12%, eigen = 1.005). Therefore, the item could load under the critical thinking domain upon EFA with a larger sample but also may stand as an indicator of communication in its current form. The researcher simplified the item's wording (*Planning extracurricular activities through online* platforms) for pilot testing. All factor loadings and their cross loadings in the collaboration domain appear in Table 19.

Table 19

Factor Loadings in the Communication Domain and Their Cross Loadings

Item No.	**Description**	**Comm**	**Var (%)**	**Eigen**	**CROSSLOADINGS**	**Collab**	**Crit Think**	**Creat**	**Cont Mast**	**Dig Lit**
12	Developing digital models to represent concepts studied.	.881	39.84	13.55			.728			
10	Applying what's been learned in class to real-world situations.	.868	17.72	6.024						.694
3	Using a digital device for real-world tasks.	.859	5.54	1.884						
11	Independently assessing information for reliability.	.868	4.37	1.487		.876		.820		
24	Choosing appropriate websites to help with learning.	.839	4.16	1.415			.659			
19	Using online resources to develop wider perspectives.	.837	3.27	1.112					.734	

Note. Comm: communication; Var: variance; Eigen: eigenvalue; Collab: collaboration; Crit Think: critical thinking; Creat: creativity; Cont Mast: content mastery; Dig Lit: digital literacy

The S-CVI/Ave for this domain in step one phase two was calculated as .80, which conveys excellent validity and suggests that this domain can be measured with the proposed instrument. Multiple items in this domain saw mean perceptions of communication significantly higher than those of content mastery, digital literacy, and creativity but not collaboration, which aligns with communication in most 21st century skill models. This finding will be discussed further in chapter six.

Content Mastery Domain

During the qualitative phase of research, 10 common items emerged as indicators of content mastery in students attending one-to-one initiative high schools. Participants in the qualitative phase of the current study identified using a school device for learning in core classes (math, science, English, etc.) (CM1) and non-core classes (music, art, PE, health, etc.) (CM2), using technology and websites to independently learn class content (CM3) and review class content (CM4), choosing appropriate websites to help with learning (CM5), finding websites to make content more meaningful (CM6) and understandable (CM7), using a school device to understand school-related material better (CM8), considering opinions on both sides of an issue (CM9), and using a school device to apply what's been learned in class to real world situations as indicators of content mastery in one-to-one initiatives. Items CM1, CM2, CM3, CM4, and CM9 were all eliminated after phase two step one due to low I-CVI scores. MKs were not calculated for these items (Table 20). The S-CVI/Ave for retained items in this domain was calculated as .74, which is adequate, suggesting that items in this domain express content mastery.

Table 20

Content Mastery Domain Item Scores

No.	Item	Strong (n)	Mod (n)	Weak (n)	Mean	MK	I-CVI	Clear (n)	Unclear (n)	Step 1 Action	Survey No.
CM1	Using a school device for learning in core classes (math, science, English, etc.)	6	5	0	7.18	NC	.091	11	1	Eliminate	N/A
CM2	Using a school device for learning in non-core classes (music, art, PE, health, etc.)	4	4	3	6.18	NC	-.273	11	1	Eliminate	N/A
CM3	Using technology and websites to independently learn class content	6	4	1	7.18	NC	.091	11	1	Eliminate	N/A
CM4	Using technology and websites to independently review class content	7	4	0	7.64	NC	.273	11	1	Eliminate	N/A
CM5	Choosing appropriate websites to help with learning	10	1	0	8.27	.64	.81	12	0	Include	24
CM6	Using a school device to find websites to make content more meaningful	9	2	0	8.82	.64	.636	12	0	Include	30
CM7	Using a school device to find websites to make content more understandable	10	1	0	9	.64	.81	12	0	Include	34
CM8	Using a school device to understand school-related material better	9	2	0	8.82	.64	.636	12	0	Include	18
CM9	Considering opinions on both sides of an issue	8	2	1	7.73	NC	.455	12	0	Eliminate	N/A
CM10	Using a school device to apply what's been learned in class to real world situations.	10	1	0	8.82	.64	.81	12	0	Include	10

Note. MK: modified kappa; I-CVI: item content validity index; No.: number; N/A: not applicable; NC: not calculated

CM7/Item 34 (*Using a school device to find websites to make content more understandable*) displayed high validity (MNR = 9; I-CVI = .81) and an acceptable MK (.64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 9.963$, $P = 0.000$, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting content mastery ($M = 4.09$; $SD = .925$) were significantly higher than those of collaboration ($M = 3.30$; $SD = 1.295$; $P = 0.006$), communication ($M = 3.09$; $SD = 1.418$; $P = 0.001$), and creativity displayed strong validity (MNR = 8.82; I-CVI = .81) and good reliability (MK = .64).
($M = 3.42$; $SD = 1.247$; $P = 0.023$). Item 34 cross loaded on collaboration (.869, variance = 2.69%, eigen = 1.162) and creativity (.777, variance = 3.02%, eigen = 1.028), suggesting the need for rewording or a reconsideration of the domain in which this item currently appears. Consequently, the researcher reworded the item for pilot testing (*Using search results to help with learning*).

For CM10/Item 10 (*Using a school device to apply what's been learned in class to the real world*), an ANOVA revealed a significant difference of means within the item, $F(5, 312) = 8.320$, $P = 0.000$, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting content mastery ($M = 4.15$; $SD = .818$) were significantly higher than those of communication (M = 3.38; SD = 1.319; $P = 0.006$), collaboration ($M = 3.34$; $SD = 1.208$; $P = 0.001$), and digital literacy ($M = 3.15$; $SD = 1.262$; $P = 0.000$). A preliminary EFA revealed that item 10 loaded strongly on communication (.868, variance = 17.72%, eigen = 6.024) and moderately on digital literacy (.694, variance = 3.96%, eigen = 1.345). The researcher reworded this item (*Connecting school work to the real world*) for pilot testing.

CM8/Item 18 (*Using a school device to understand school-related material better*) displayed moderate validity and good reliability (MNR = 8.82; I-CVI =.636; MK = .64). An

ANOVA revealed a significant difference of means within the item, *F*(5, 312) = 5.781, *P* = 0.000, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting content mastery (*M* = 3.94; *SD* = .974) were significantly higher than those of collaboration (M = 3.34; SD = 1.219; *P* = 0.011). Although the difference was not significant, the mean of this item as a perception of digital literacy (*M* = 4.25, *SD* = .875) was higher than that of content mastery, suggesting that this item may express digital literacy. A preliminary EFA showed that item 18 loaded strongly on both critical thinking (.774; variance = 17.46%; eigen = 5.937) and collaboration (.914, variance = 39%, eigen = 13.262) suggesting that this item may represent critical thinking or collaboration rather than content mastery. Given these findings, the researcher simplified this item's wording (*Using websites to help with homework*) in anticipation of pilot testing with a larger sample.

CM6/Item 30 (*Using a school device to find websites to make content more meaningful*) displayed moderate validity (MNR: 8.82; I-CVI =.636; MK = .64). An ANOVA revealed a significant difference of means within the item, *F*(5, 312) = 6.175, *P* = 0.000, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting content mastery (*M* = 3.91; *SD* = .883) were significantly higher than those of communication (*M* = 3.25; *SD* = 1.314; *P* = .036) and collaboration (*M* = 3.08; *SD* = 1.190; *P* = 0.031). Although the difference was not significant, the mean of this item as a perception of digital literacy (*M* = 4.13, *SD* = .900) was higher than that of content mastery, suggesting that this item might reflect digital literacy rather than content mastery. A preliminary EFA showed that item 30 cross loaded on collaboration (.869; variance = 4.8%; eigen = 1.630), critical thinking (.672, variance = 2.94%, eigen = 1.109), and creativity (.773; variance = 2.94%; eigen = 1.00) suggesting that this item may load on one of these domains rather than content mastery. Given these findings, the researcher reworded the item (*Finding websites that make schoolwork meaningful*) in anticipation of input from a larger sample.

CM5/Item 24 (*Choosing appropriate websites to help with learning*) displayed high validity (MNR = 8.27; I-CVI = .81; MK = .64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 8.810$, $P = 0.000$, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting content mastery ($M = 3.83$; $SD = .935$) were significantly higher than those of communication ($M = 3.08$; $SD = 1.357$; $P = .015$) and collaboration ($M = 3.15$; SD = 1.199; $P = 0.019$). Although the difference was not significant, the mean of this item as a perception of digital literacy ($M = 4.30$, $SD = .799$) was higher than that of content mastery, suggesting that, like other items in this domain, item 24 might reflect digital literacy rather than content mastery. A preliminary EFA showed that item 24 cross loaded on communication (.839; variance = 4.16%; eigen = 1.415) and critical thinking (.659, variance = 3.12%, eigen = 1.005). Given these findings, the researcher reworded this item to be more specific (*Learning through online sources*) for pilot testing. All factor loadings and their cross loadings in the content mastery domain appear in Table 21.

Table 21

Factor Loadings in the Content Mastery Domain and Their Cross Loadings

No.	Description	Cont Mast	Var (%)	Eigen	CROSSLOADINGS	Collab	Comm	Crit Think	Creat	Dig Lit
33	Participating in class-related discussion boards to learn more about what others think.	.773	37.55	12.766					.828	.643
26	Arranging and carrying out tasks that require group work.	.759	9.87	3.356						
7	Asking questions of teachers and other students outside of class time through email or discussion boards.	.748	7.50	2.551						.749
19	Using online resources to develop wider perspectives.	.734	4.82	1.638			.837			
25	Using email or discussion boards to contact teachers outside of school hours.	.723	4.48	1.523		.820		.690		
34	Finding websites that help make studied content more understandable.	.712	3.77	1.282		.868		.728		
13	Discussing (face-to-face and through digital platforms) approaches to problem solving.	.706	3.56	1.209						
15	Effectively negotiating media sources (e.g. recognize bias, choose appropriate online sources, use keywords, etc.).	.694	3.32	1.130					.773	.810

Note. Cont Mast: content mastery; Var: variance; Eigen: eigenvalue; Collab: collaboration; Comm: communication; Creat: creativity; Critical Think: critical thinking; Dig Lit: digital literacy

As stated earlier, the S-CVI/Ave for content mastery was .76, which suggests that these items adequately reflect content mastery in high school one-to-one initiatives. However, items in this domain frequently cross loaded on digital literacy. Chapter six focusses on this point further.

Creativity Domain

During the qualitative phase of research, nine common items emerged as indicators of highly creative abilities in one-to-one initiative high schools. Participants in the qualitative phase of the current study identified doing "artsy" projects (for example, sketching, composing music, drawing, painting, etc.) through a school device (CRTV1); taking creative, online approaches to academic assignments (CRTV2); solving problems encountered in the digital world (blocked websites, password protected domains, etc.) through creative approaches (CRTV3); creating new ways to do things online (redesigning hardware, programming, coding, etc.) (CRTV4); engaging in creative thinking, writing, and speaking (CRTV5); dealing with problems or confusion that arises when moving between online platforms (CRTV6); creating multimedia presentations (CRTV7); creating digital models to represent concepts studied (CRTV8); and creating products beyond teacher-defined parameters (CRTV9) as indicative of abilities associated with creativity. SMEs determined that all items were clearly worded, except for CRTV1 and CRTV6, both of which were eliminated in addition to CRTV2 and CRTV5, due to unacceptably low I-CVIs (Table 22). The S-CVI/Ave for retained items in this domain was calculated as .81, suggesting that this domain has excellent validity.

Table 22

Creativity Domain Item Scores

No.	Item	Strong (n)	Mod (n)	Weak (n)	Mean	Kappa	I-CVI	Clear (n)	Unclear (n)	Step 1 Action	Survey No.
CRTV1	Doing "artsy" projects (for example, sketching, composing music, drawing, painting, etc.) through a school device	7	4	0	7.55	NC	.273	10	2	Eliminate	N/A
CRTV2	Taking creative, online approaches to academic assignments	8	3	0	7.64	NC	.455	11	1	Eliminate	N/A
CRTV3	Solving problems encountered in the digital world (blocked websites, password protected domains, etc.) through creative approaches	10	1	0	8.9	.81	.81	11	1	Include	1
CRTV4	Creating new ways to do things online (redesigning hardware, programming, coding, etc.)	9	2	0	8.73	.64	.636	12	0	Include	14
CRTV5	Engaging in creative thinking, writing, and speaking	8	3	0	8.09	NC	.455	12	0	Eliminate	N/A
CRTV6	Dealing with problems or confusion that arises when moving between online platforms	7	4	0	7.82	NC	.273	10	2	Eliminate	N/A
CRTV7	Creating multimedia presentations	10	1	0	8.64	.81	.81	12	0	Include	5
CRTV8	Creating digital models to represent concepts studied	11	0	0	9.09	.82	1	12	0	Include	12
CRTV9	Creating products beyond teacher-defined parameters	10	1	0	9.45	.81	.81	12	0	Include	23

Note. MK: modified kappa; I-CVI: item content validity index; No.: number; N/A: not applicable; NC: not calculated

CRTV9/Item 21 (*Creating products beyond teacher-defined parameters*) had high validity (MNR = 9.45; I-CVI = .81; MK = .81) but was reworded for step two phase two (*Innovating products beyond teacher-defined parameters*) to avoid biased language. Further analyses revealed a significant difference of means within the item, $F(5, 312) = 4.389$, $P = 0.001$, and a Games-Howell post hoc test showed a significantly higher mean of the item expressing creativity ($M = 3.89$, $SD = 1.293$) over collaboration ($M = 3.21$; $SD = 1.215$; $P = 0.031$) or communication ($M = 3.11$, $SD = 1.251$, $P = 0.01$). The preliminary EFA found that this item failed to load under any factors, suggesting that it may not reflect creativity within one-to-one initiative high schools. However, it might benefit from further analyses with an EFA performed with a larger sample, especially in consideration of the lack of a statistical difference between perceptions of it and those of digital literacy, content mastery, and critical thinking.

SMEs indicated that CRTV8/Item 12 (*Creating digital models to represent concepts studied*) had high validity and excellent reliability (MNR = 9.09; I-CVI = .92; MK = 1). Further analyses revealed a significant difference of means within the item, $F(5, 312) = 10.973$, $P = 0.000$, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting creativity were higher than all other domains and significantly higher than those of communication ($M = 3.04$; $SD = 1.386$; $P = 0.000$) and collaboration ($M = 3.13$; $SD = 1.272$; $P = 0.000$). Despite these findings, the preliminary EFA found that this item loaded very strongly under communication (.881, variance = 39.84%, eigen = 13.55), suggesting that this item may more accurately reflect communication than creativity. The researcher reworded the item (*Developing virtual models of studied concepts*), anticipating EFA with a larger sample.

CRTV3/Item 1 (*Solving problems encountered in the digital world [blocked websites, password protected domains, etc.] through creative approaches*) had high validity as an indicator of creativity (MNR = 8.9; I-CVI = .81; MK = .81). However, for step two, “through creative approaches” was removed from the item to avoid biased language. Further analyses revealed a significant difference of means within the item, $F(5, 312) = 6.976$, $P = 0.000$; however, a Games-Howell post hoc test revealed that mean perceptions of this item reflecting creativity were not significantly higher than those of any other domain. In addition, this item did not load under any factors, suggesting that statistically speaking this item may not be an indicator of 21st century skills in one-to-one initiative high schools. However, the researcher retained the item in the creativity domain for pilot testing due to its high validity and reliability. In addition, the researcher reworded the item (*Solving digital world problems [blocked websites, password protected domains, etc.]*).

CRTV4/Item 14 (*Creating new ways to do things online [redesigning hardware, programming, coding, etc.]*) had a high MNR (8.73), an acceptable I-CVI (.636), and a good MK (.64), but the researcher changed wording before step two to avoid biased language (“creating” became “engineering”). Further analyses revealed higher means of perceptions of this item expressing creativity than any other domain, and an ANOVA showed a significantly higher difference of means within the item, $F(5, 312) = 8.096$, $P = 0.000$. A Games-Howell post hoc test revealed that mean perceptions of this item reflecting creativity were significantly higher than those of communication ($M = 3.34$; $SD = 1.315$; $P = 0.000$), collaboration ($M = 3.32$; $SD = 1.341$; $P = 0.000$), and content mastery ($M = 3.72$; $SD = 1.063$; $P = 0.004$). This item did not load under any factors upon a preliminary EFA; however, this item might benefit from further analyses with a larger sample given the findings of the post hoc test.

CRTV7/Item 5 (*Creating multimedia presentations*) had high validity and excellent reliability (MNR = 8.64; I-CVI = .81; MK = .81) but was reworded for step two to avoid biased language and to qualify the item ("generating engaging" was added to the front of the item). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 8.460$, $P = 0.000$, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting creativity were significantly higher than those of communication ($M = 3.91$; $SD = 1.061$; $P = 0.007$), collaboration ($M = 3.74$; $SD = 1.059$; $P = 0.000$), critical thinking ($M = 3.75$; $SD = .998$; $P = 0.000$), or content mastery ($M = 3.57$; $SD = 1.201$; $P = 0.000$). A preliminary EFA of this item showed that it loaded moderately on critical thinking (.659, variance = 4.97%, eigen = 1.689) suggesting that this item may reflect critical thinking rather than creativity. Pilot testing with a larger sample would yield more reliable results. All creativity domain factor loadings and their cross loadings appear in Table 23.

Table 23

Factor Loadings in the Creativity Domain and Their Cross Loadings

No.	**Description**	**Creat.**	**Var (%)**	**Eigen**	**CROSSLOADINGS**	**Collab**	**Comm**	**Crit Think**	**Cont Mast**	**Dig Lit**
4	Receiving feedback from schoolmates (face-to-face and through digital platforms) on school assignments.	.879	42.97	14.611					.712	
32	Giving feedback to peers (face-to-face and through digital platforms) on school assignments.	.828	7.76	2.637						.806
29	Asking relevant questions during class.	.827	6.52	2.217						
11	Independently assessing information for reliability.	.820	6.07	2.064		.876	.868			
25	Using email or discussion boards to contact teachers outside of school hours.	.820	4.35	1.4789		.820		.690	.723	
33	Participating in class-related discussion boards to learn more about what others think.	.810	3.5	1.183					.773	.643
34	Finding websites that help make studied content more understandable.	.777	3.02	1.028		.869		.728		
30	Being able to find websites to make classroom content more meaningful.	.773	2.94	1.00		.889		.672		

Note. Creat = creativity; Var = variance; Eigen = eigenvalue; Collab = collaboration; Comm = communication; Critical Think = critical thinking; Cont Mast = content mastery; Dig Lit = digital literacy

As mentioned earlier, the S-CVI/Ave for this domain was .81, suggesting excellent reliability and validity. Statistical analyses revealed items in this domain frequently aligned with critical thinking and digital literacy. This finding will be discussed further in chapter six.

Digital Literacy Domain

During the qualitative phase of research, 13 common items emerged as indicators of digital literacy in students attending one-to-one initiative high schools. Participants in the qualitative phase of the current study identified using a school device for school-based tasks (DL1), choosing when to use paper and pencil to complete an assignment versus when to use a school device (DL2), fact checking others' information using online resources during class-based discussions (DL3), using a school device for real-world tasks (DL4), effectively using keyword searches to find useful websites (DL5), effectively managing time when working on a school device (DL6), creating multimedia presentations (DL7), assessing online information for reliability (DL8), using online resources to carry out research (DL9), sending/receiving emails through a school device (DL10), independently dealing with questionable or doubtful information (DL11), independently dealing with biased information (DL12), and effectively negotiating media (e.g. recognizing bias, choosing appropriate online sources, etc.) (DL13) as indicative of digital literacy (Table 24).

Table 24

Digital Literacy Domain Item Scores

No.	Item	Strong (n)	Mod (n)	Weak (n)	Mean	Kappa	I-CVI	Clear (n)	Unclear (n)	Survey No.	Step 1 Action
DL1	Using a school device for school-based tasks	8	2	1	7.91	NC	.455	12	0	N/A	Eliminate
DL2	Choosing when to use paper and pencil to complete an assignment versus when to use a school device.	7	2	2	6.82	NC	.273	11	1	N/A	Eliminate
DL3	Fact checking others' information using online resources during class-based discussions	8	3	0	8.72	NC	.455	12	0	N/A	Eliminate
DL4	Using a school device for real-world tasks	9	2	0	8.64	.64	.636	12	0	3	Include
DL5	Effectively using keyword searches to find useful websites	8	3	0	8.45	NC	.455	12	0	N/A	Eliminate
DL6	Effectively managing time when working on a school device.	8	3	0	8.45	NC	.455	12	0	N/A	Eliminate
DL7	Creating multimedia presentations	11	0	0	9.18	.64	1	12	0	N/A	Eliminate (redundant)
DL8	Assessing online information for reliability	11	0	0	9.09	.64	1	12	0	2	Include
DL9	Using online resources to carry out research.	10	1	0	8.82	.64	.81	12	0	28	Include
DL10	Sending/receiving emails through a school device	7	4	0	7.73	NC	.273	11	1	N/A	Eliminate
DL11	Independently dealing with questionable, doubtful, information.	9	1	1	7.91	.64	.636	10	2	11	Include (reword)
DL12	Independently dealing with biased information	8	2	1	7.64	NC	.455	10	2	N/A	Eliminate
DL13	Effectively negotiating media (e.g. recognizing bias, choosing appropriate online sources, etc.).	10	1	0	9.09	.64	.81	12	0	15	Include

Note. MK: modified kappa; I-CVI: item content validity index; No.: number; N/A: not applicable; NC: not calculated

SMEs determined that all items except for DL11 and DL12 were clearly worded. Items DL1, DL2, DL3, DL5, DL6, DL10, and DL12 were all eliminated after phase one step one due to low I-CVI scores. DL7 was eliminated due to redundancy. MKs were not calculated for these items. The S-CVI/Ave for retained items in this domain was calculated as .81, which is excellent.

DL8/Item 2 (*Assessing online information for reliability*) had high validity (MNR = 9.09; I-CVI = 1) but displayed a moderate MK coefficient (.64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 9.187$, $P = 0.000$, and a Games-Howell post hoc test revealed a significantly higher perception of this item describing digital literacy ($M = 4.32$, $SD = .754$) than collaboration ($M = 3.26$; $SD = 1.258$; $P = 0.000$), communication ($M = 3.08$; $SD = 1.357$; $P = 0.000$), critical thinking ($M = 3.74$; $SD = 1.195$; $P = 0.038$), creativity ($M = 3.08$; $SD = 1.253$; $P = 0.000$), and content mastery ($M = 3.70$; $SD = 1.085$; $P = 0.011$). However, a preliminary EFA of this item showed that it did not load cleanly on any factors. The significant differences between all domains, however, would suggest that it addresses digital literacy. Pilot testing with a larger sample would yield more reliable results.

DL13/Item 15 (*Effectively negotiating media [e.g. recognizing bias, choosing appropriate online sources, etc.*]) displayed strong validity (MNR = 9.09; I-CVI = .81) and an acceptable MK coefficient (.64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 5.815$, $P = 0.000$, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting digital literacy ($M = 4.30$; $SD = .749$) were significantly higher than those of communication ($M = 3.53$; $SD = 1.234$; $P = 0.003$), collaboration ($M = 3.28$; $SD = 1.292$; $P = .000$), creativity ($M = 3.68$; $SD = 1.015$; $P = .007$), and content mastery ($M = 3.55$; $SD = .998$; $P = .002$). A preliminary EFA of this item showed that it did not load cleanly on any factors. The significantly higher means between digital literacy and four domains, however, would suggest that item 15 addresses digital literacy. Thinking the item's wording may be overly complex, the researcher simplified the item for pilot testing (*Recognizing bias in media*) and eliminated the second part of the item due to redundancy with item 28. Pilot testing, therefore, might yield more reliable results.

DL9/Item 28 (*Using online resources to carry out research*) had high validity (MNR = 8.82; I-CVI = .81) and an acceptable MK coefficient (.64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 7.426$, $P = 0.000$, and a Games-Howell post hoc test revealed that the mean perception of this item reflecting digital literacy ($M = 4.28$; $SD = .818$) was significantly higher than those of communication ($M = 3.23$; $SD = 1.396$; $P = 0.000$), collaboration ($M = 3.15$; $SD = 1.262$; $P = 0.000$), critical thinking ($M = 3.62$; $SD = 1.113$; $P = 0.010$), and creativity ($M = 3.47$; $SD = 1.137$; $P = 0.001$). A preliminary EFA of this item showed that it loaded strongly on critical thinking (.721, variance = 5.725%, eigen = 1.947) and collaboration (.876; variance = 4.28%; eigen = 1.456) suggesting that this item may benefit from rewording. The modified wording (*Choosing online sources for research*) pilot tested with a larger sample would possibly yield different results.

DL4/Item 3 (*Using a school device for real-world tasks*) had high validity (MNR = 8.64; I-CVI = .636) and good reliability (MK = .64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 5.257$, $P = 0.000$, and a Games-Howell post hoc test revealed that the mean perceptions of this item reflecting digital literacy ($M = 4.25$; $SD = .806$) were significantly higher than those of communication ($M = 3.11$; $SD = 1.396$; $P = 0.000$), collaboration ($M = 3.43$; $SD = 1.294$; $P = 0.003$), critical thinking ($M = 3.53$; $SD = 1.170$; $P = 0.005$), creativity ($M = 3.68$; $SD = 1.105$; $P = 0.038$), and content mastery ($M = 3.60$; $SD = 1.230$; $P = 0.024$). Item 3 loaded moderately on communication (.859; variance = 5.54%; eigen =

1.884) without cross loading under any other domains, suggesting that this item may reflect communication rather than digital literacy. EFA with a larger sample may yield different results. SMEs assessed DL11/Item 11 (*Independently dealing with questionable or doubtful information*) with moderate validity and good reliability (mean: 7.91; I-CVI = .64; MK = .636). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 9.468$, $P = 0.000$, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting digital literacy ($M = 3.91$; $SD = .861$) were significantly higher than those of critical thinking ($M = 3.13$; $SD = 1.210$; $P = 0.003$), creativity ($M = 2.92$; $SD = 1.284$; $P = 0.000$), and content mastery ($M = 2.87$; $SD = 1.415$; $P = 0.000$). Item 11 cross loaded on communication (.868; variance = 4.37%; eigen = 1.487), collaboration (.876, variance = 3.42%, eigen = 1.226), and creativity (.820, variance = 6.07%, eigen = 2.064), suggesting that the item's wording may be unclear or that the item expresses a domain other than digital literacy. This item expressed a higher mean perception of communication ($M = 3.96$; $SD = 1.386$), suggesting that the item might load most strongly on communication upon pilot testing. For pilot testing, the researcher simplified the item's wording (*Independently dealing with doubtful information*). All digital literacy domain factor loadings and their cross loadings appear in Table 25.

Table 25

Factor Loadings in the Digital Literacy Domain and Their Cross Loadings

No.	**Description**	**Creat.**	**Var (%)**	**Eigen**	**CROSSLOADINGS**	**Collab**	**Comm**	**Crit Think**	**Cont Mast**	**Creat**
32	Giving feedback to peers (face-to-face and through digital platforms) on school assignments.	.806	28.38	9.650						.828
23	Working together with classmates (face-to-face and in digital environments) on graded assignments.	.790	20.37	6.926						
7	Asking questions of teachers and other students outside of class time through email or discussion boards.	.749	7.00	2.378					.748	
27	Working together with classmates (face-to-face and in digital environments) on extracurricular projects/assignments.	.734	6.14	2.086						
6	Discussing (face-to-face and through digital platforms) research findings with teachers and other students.	.717	4.27	1.452						
10	Applying what's been learned in class to real-world situations.	.694	3.96	1.345		.868				
13	Discussing (face-to-face and through digital platforms) approaches to problem solving.	.672	3.44	1.070						
33	Participating in class-related discussion boards to learn more about what others think.	.643	3.00	1.020					.773	.810

Note. Dig Lit = digital literacy; Var = variance; Eigen = eigenvalue; Collab = collaboration; Comm = communication; Creat = creativity; Critical Think = critical thinking; Cont Mast = content mastery

Digital literacy in the quantitative phase of the study expressed as a domain marked by real-world connections and recognizing bias and reliability in paper-based and online resources. Interestingly, within this domain, perceptions of items as indicators of digital literacy differed significantly from those of content mastery. Chapter six will offer a more in-depth interpretation of this finding.

Expanded Thinking/Critical Thinking Domain

Although participants in the qualitative phase of research described this domain as expanded thinking, SMEs indicated confusion around this term. Therefore, in the quantitative data collection this domain's name was changed to "critical thinking." The item labels in phase two step one remained as ET but, in phase two step two, the items are referred to as belonging to the domain labeled critical thinking.

During the qualitative phase of research, 10 common items emerged as indicators of expanded thinking in students attending one-to-one initiative high schools. Participants in the qualitative phase of the current study identified staying focused on what peers share in class (ET1), determining the reliability of online information (ET2), asking relevant questions during class (ET3), staying focused on what teachers teach during class (ET4), mustering self-motivation to be interested in what is being covered in class (ET5), participating in class-related discussion boards to learn more about what others think (ET6), using online resources to develop wider perspectives (ET7), thinking deeply about information encountered online (ET8), thinking critically about information encountered online (ET9), and using a school device to apply what's been learned in class to real world situations (ET10) as indicators of expanded thinking in one-to-one initiative high schools (Table 26). ET1 had a low MNR (M = 7.09), and ET2 had a high MNR (M = 8.09), but the I-CVIs for both items were unacceptably low (.091 and .455, respectively) so both were eliminated in phase two step one. The S-CVI/Ave for included items in this domain was calculated as .71, which is acceptable.

Table 26

Expanded Thinking/Critical Thinking Domain Item Scores

No.	Item	Strong (n)	Mod (n)	Weak (n)	Mean	MK	I-CVI	Clear (n)	Unclear (n)	Step 1 Action	Survey No.
ET1	Staying focused on what peers share in class	6	5	0	7.09	NC	.091	12	0	Eliminate	N/A
ET2	Determining the reliability of online information	8	3	0	8.09	NC	.455	12	0	Eliminate	N/A
ET3	Asking relevant questions during class	9	2	0	8.36	.64	.636	12	0	Include	29
ET4	Staying focused on what teachers teach during class	10	1	0	8	.81	.81	12	0	Include	22
ET5	Mustering self-motivation to be interested in what is being covered in class	9	2	0	7.8	.64	.636	12	0	Include	31
ET6	Participating in class-related discussion boards to learn more about what others think	9	2	0	8.5	.64	.636	12	0	Include	33
ET7	Using online resources to develop wider perspectives	9	2	0	8.7	.64	.636	10	2	Include	19
ET8	Thinking deeply about information encountered online	10	1	0	8.7	.64	.81	10	2	Include	16
ET9	Thinking critically about information encountered online	10	1	0	8.7	.64	.81	11	1	Include	20
ET10	Using a school device to apply what's been learned in class to real world situations.	10	1	0	8.6	.64	.81	11	1	Eliminate (redundant)	N/A

Note. MK: modified kappa; I-CVI: item content validity index; No.: number; N/A: not applicable; NC: not calculated

ET8/Item 16 (*Engaging deeply and thoughtfully with information encountered online*) had high validity and reliability (MNR = 8.7; I-CVI = .81; MK = .64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 5.497$, $P = 0.000$, and a Games-Howell post hoc test revealed that the mean perception of this item reflecting critical thinking ($M = 4.19$; $SD = .833$) was significantly higher than that of collaboration ($M = 3.28$; $SD = 1.246$; $P = 0.034$). Although the difference was not significant, the mean of this item as a perception of digital literacy ($M = 4.17$, $SD = .727$) was higher than that of critical thinking. A preliminary EFA showed that item 16 did not load cleanly on any factors, suggesting that the qualitative finding of the study may not be generalizable to a population level or that the item needed rewording. The researcher simplified the item (*Engaging thoughtfully with information encountered online*). Pilot testing with a larger sample might yield different results.

SMEs rated ET9/Item 20 (*Thinking critically about information encountered online*) as having high validity and reliability (MNR = 8.7; I-CVI = .81; MK = .64). However, the researcher reworded the item for step two (*Using information encountered online to consider opinions and perspectives from multiple angles*) to provide more specificity based on SME feedback. An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 4.870$, $P = 0.000$, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting critical thinking ($M = 4.19$; $SD = .833$) were significantly higher than those of communication ($M = 3.53$; $SD = 1.234$; $P = .021$), collaboration ($M = 3.55$; SD = 1.202; $P = 0.023$), and creativity ($M = 3.62$; $SD = 1.060$; $P = .033$). Although the difference was not significant, the mean of this item as a perception of digital literacy ($M = 4.21$, $SD = .793$) was higher than that of critical thinking. A preliminary EFA showed that item 20 did not load cleanly on any factors, suggesting that this qualitative finding may not be generalizable to a population level or may benefit from rewording. The researcher simplified this item's wording, therefore, for pilot testing (*Considering others' opinions and perspectives*).

SMEs rated ET7/Item 19 (*Using online resources to develop wider perspectives*) as having moderate validity and good reliability (MNR = 8.7; I-CVI = .636; MK = .64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 5.807$, $P = 0.000$. However, a Games-Howell post hoc test revealed no significant difference in means of perception in this item reflecting critical thinking versus different 21st century skills. This finding suggested that this item might benefit from rewording; therefore, the researcher simplified the item (*Expanding perspectives through online interactions*) for pilot testing.

ET4/Item 22 (*Staying focused on what teachers teach during* class) had an acceptable level of validity and good reliability (MNR = 8.36; I-CVI = .636; MK = .64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 2.712$, $P = 0.02$. However, as with item 19, a Games-Howell post hoc test revealed that mean perceptions of this item reflecting critical thinking ($M = 3.74$; $SD = 1.047$) were not significantly higher than the means of other skills. A preliminary EFA showed the item did not load cleanly on any factors, suggesting that this qualitative finding may not be generalizable to a population level. These findings led the researcher to reword the item (*Maintaining focus during class*) due to its validity assessment.

SMEs rated ET3/Item 29 (*Asking relevant questions in class*) as having acceptable validity and good reliability (MNR = 8.7; I-CVI = .636; MK = .64). An ANOVA revealed a significant difference of means within the item, $F(5, 312) = 4.487$, $P = 0.001$, and a Games-Howell post hoc test revealed that mean perceptions of this item reflecting critical thinking ($M = 3.85$; $SD = 1.008$) were significantly higher than those of digital literacy ($M = 3.13$; $SD = 1.225$;

P = .017). The mean of the item in relation to communication (*M* = 3.98, *SD* = 1.028) and collaboration (*M* = 3.70, *SD* = 1.262), although not significant, was higher than that of critical thinking. A preliminary EFA showed that item 29 loaded cleanly on creativity (.827, variance = 6.07%, eigen = 2.064), suggesting that this item would benefit from pilot testing with a larger sample.

SMEs indicated that ET5/Item 31 (*Mustering self-motivation to be interested in what is being covered in class*) had good reliability but only acceptable validity (MNR = 7.8; I-CVI = .636; MK = .64). An ANOVA revealed a relatively low but significant difference of means within the item, *F*(5, 312) = 2.302, *P* = 0.045. However, a Games-Howell post hoc test revealed that mean perceptions of this item reflecting critical thinking (*M* = 3.53; *SD* = 1.103) were not significantly different from those of any of the other five 21st century skills. These findings suggest that this item's results differ from the qualitative findings, so this phenomenon may not be characteristic of 21st century skills in one-to-one initiatives at a population level. Therefore, this item was eliminated from consideration for inclusion in pilot testing.

ET6/Item 33 (*Participating in class-related discussion boards to learn more about what others think*) had a relatively high MNR (8.5) and good reliability (.64) and acceptable validity (I-CVI = .636). An ANOVA revealed a significant difference of means within the item, *F*(5, 312) = 6.713, *P* = 0.000. A Games-Howell post hoc test, however, revealed that mean perceptions of this item reflecting critical thinking (*M* = 4.09; *SD* = .741) were not significantly higher than means of any of the other five 21st century skills. However, mean perceptions of this item representing communication (*M* = 4.45, *SD* = .774) were significantly higher than those of digital literacy (*M* = 3.81; *SD* = 1.210; *P* = .02), creativity (*M* = 3.42; *SD* = 1.247, *P* = 0.001), and content mastery (*M* = 3.91; *SD* = .986; *P* = .024). A preliminary EFA showed that item 33 loaded strongly on content mastery (.773; variance = 37.55%; eigen = 12.766), and moderately on creativity (.810; variance = 3.5%; eigen = 1.183) and digital literacy (.643; variance = 3.00%; eigen = 1.020). These results suggested rewording, so the researcher simplified the item (*Eliciting others' opinions*) in anticipation of pilot testing with a larger sample and moved it to the communication domain. All digital literacy domain factor loadings and their cross loadings appear in Table 27.

Table 27

Factor Loadings in the Critical Thinking Domain and Their Cross Loadings

Item No.	**Description**	**Crit Think**	**Var (%)**	**Eigen**		**Collab**	**Comm**	**Creat**	**Cont Mast**	**Dig Lit**
34	Developing digital models to represent concepts studied.	.728	32.08	10.906		.869		.777	.712	
18	Applying what's been learned in class to real-world situations.	.774	17.46	5.937		.914				
12	Using a digital device for real-world tasks.	.728	6.81	2.314			.881			
28	Independently assessing information for reliability.	.721	5.73	1.947		.887				
5	Generating engaging multimedia presentations.	.659	4.97	1.689	***CROSSLOADINGS***					
25	Choosing appropriate websites to help with learning.	.690	3.57	1.215		.820		.690	.723	
30	Using online resources to develop wider perspectives.	.672	3.26	1.109				.773		
8	Mustering self-motivation to be interested in what is being covered in class.	.659	3.12	1.060						
24	Choosing appropriate websites to help with learning.	.659	3.12	1.005			.839			

Note. Crit Think: critical thinking; Var: variance; Eigen: eigenvalue; Collab: collaboration; Comm: communication; Creat: creativity; Cont Mast: content mastery; Dig Lit: digital literacy

Items in the critical thinking domain generally reflect in and out-of-class interactions and the value of considering perspectives and opinions in a variety of contexts. These results suggest that computers in one-to-one initiatives are neither underused or overused, but that teachers have potentially found a balance between thinking with a screen and thinking without the aid of a device. This finding will be discussed further in chapter six.

Conclusion

Chapter five reported the results of quantitative analysis to answer research question three: What items in a 21st century skill-measuring instrument represent the results of the qualitative phase of research? By calculating I-CVI, MK, ANOVA, and EFA, the researcher determined that the majority of items (31/34) should be included in an instrument piloted with a larger group to analyze the loading of items within the proposed domains of the 21st century skill set (i.e., collaboration, communication, content mastery, creativity, critical thinking, and digital literacy). The results of the ANOVA and post hoc test revealed that 29 items expressed significantly higher means within the domains identified in the qualitative portion of the study. This finding suggests that the quantitative findings mirror the qualitative findings in most cases. Chapter six is dedicated to a further and more detailed discussion on these findings in relation to one-to-one initiative high schools, pedagogy, activity theory, and 21st century skill development.

CHAPTER SIX

DISCUSSION

The educational landscape is shifting in response to technology implementation, even in institutions where students do not have 24/7 access to a school-issued device. Simultaneously, schools are positioning themselves as preparers of 21st century thinkers, highlighting their dedication to developing skills for an unknown future. One-to-one initiatives would seem to hold potential to facilitate this preparation.

In contrast to this call for skill building and a focus on students' preparation for the demands of the real world, high schools in particular continue to be held accountable for students' school-based performance based on standardized test scores, and educators are under pressure to ensure that their students perform well in state testing. While past research has identified the positive effects of one-to-one initiatives on student achievement and engagement (Baines & Romano, 2015; James-Burdumy et al., 2010; Fisher & Ivey, 2006; Slavin, Lake, Davis, & Madden, 2009; Zheng, Warschauer, Lin, & Chang, 2016), additional effects, including 21st century skill development, have gone largely unaddressed in the literature despite calls by researchers.

Considering this call for an examination of the non-academic outcomes in one-to-one initiatives, this study aimed to explore perceptions of 21st century skill development in one-to-one initiative high schools and create a validated and reliable instrument to measure those skills. This research was guided by three research questions. The aim of research question one was to determine the tensions that exist between the different elements of an activity system in which one-to-one devices are the mediating artifact. Research question two focused on 21st century skills identified in one-to-one initiative high schools, and research question three focused on the relationship between qualitative and quantitative analyses.

Data collection consisted of interviews with 34 high school students and seven high school teachers from two public and one private high school on the East Coast of the United States. A second round of data collection comprised 53 undergraduates in a teacher education program. The researcher transcribed the interviews using Google's Talk-to-Text add-on and coded data using AntConc and Microsoft Excel with thematic coding based on 21st century skill literature and themes that emerged from the literature. Activity theory acted as the basis for the conceptualization of the interview protocols and helped guide sensemaking in relation to interactions between students, teachers, and the one-to-one initiatives.

The previous five chapters have built to the discussion that unfolds in chapter six. Chapter one introduced the study, while chapter two focused on literature related to one-to-one initiative outcomes, activity theory, and 21st century skill development. Chapter three detailed the study's mixed methods methodology. Chapters four and five offered qualitative and quantitative results, respectively. This chapter begins with a discussion of the qualitative and quantitative findings in light of activity theory and the 21st century skill set. Within this discussion, the following are considered: 1) how teachers and students differ and agree in their perceived skill-based outcomes when involved in one-to-one initiatives; 2) how one-to-one initiatives support 21st century skill development; and 3) how results of validation and reliability analyses relate to qualitative findings. The chapter concludes with a discussion of the implications of the current research for high schools involved in one-to-one initiatives.

Students' and Teachers' Perceptions of Skills-Based Outcomes

Although teachers and students involved in one-to-one initiatives share common devices, in-school access, and technology, the students and teachers often differed in their fundamental perceptions of outcomes, meanings, and uses of the initiatives. Through the lens of activity theory, it is understood how tensions, or interactions, between the parties involved in one-to-one initiatives affect outcomes of those initiatives. As discussed in chapter two, literature on one-to-one initiatives indicates that students involved in one-to-one initiatives are more engaged in school and have higher academic achievement than their peers who are not involved in such initiatives (Baines & Romano, 2015; James-Burdumy et al., 2010; Fisher & Ivey, 2006; Slavin, Lake, Davis, & Madden, 2009; Zheng, Warschauer, Lin, & Chang, 2016). Considering the fact that researchers have consistently pointed to this finding, it was surprising that no participants explicitly mentioned academic achievement as a perceived outcome of their one-to-one initiatives. Instead, teachers and students pointed to characteristics that suggest a slow transition occurring in one-to-one initiatives schools.

In 1985, Grabe noted that classroom technology use was strongly instructor driven and isolated from the usual goings-on of classrooms, with teachers controlling the manner in which students interacted with computers. Grabe also noted that classroom technology use focused on worksheet-making programs and other approaches that placed students in the role of consumer rather than creator. Given the age of Grabe's study, it is not surprising that the findings of the current study pointed to a shift away from instructor-driven instruction in one-to-one initiatives. This finding held true, however, only in high school teachers in this study who had embraced the devices and the potential held for skill development.

In every school, students could easily identify teachers who did not use technology at all, or who used it for just one purpose (for example, just to project PowerPoint slides in class). These teachers did not allow devices to be used during class and required students to hand write notes. Interestingly, in all three schools, students discussed teachers citing research that proved that hand writing results in better information retention than typing. Students in all three schools also discussed their own anecdotal observations around handwriting versus typing. Students and teachers were very obviously involved in tension-filled relationships with the extent to which they were willing to integrate technology into the classroom.

In classrooms where teachers had made the shift toward supporting skills, instruction and the classroom layout focused on small group activities and collaborative meaning making in addition to teacher-led instruction. Teachers in these classrooms offered instruction that integrated technology but did not rely exclusively on technology. The focus in these classrooms was on what students could do with knowledge beyond the artificial construct of exams and graded assignments that are a familiar part of the educational landscape, which is in agreement with the findings of Silva (2009).

Part of students learning in a one-to-one initiative high school, therefore, is exploring every teacher's limit of acceptance for technology use in class. Additionally, students must learn and then remember which teachers prefer which communication platforms. Students described some teachers preferring email communication and others opting for learning management systems. Some teachers indicated distaste for any technology-based communication and required students to conduct all business face-to-face. Students, therefore, must exercise communication, collaboration, and critical thinking skills as they assess a teacher's position on what constitutes acceptable technology use and communication.

This finding clearly points to the fact that some educators are reluctant to deviate from traditional classroom foci. Prensky (2001) explained such behavior based on a person's age and background, with individuals being either "digital natives" or "digital immigrants". Observations and interviews suggest though that acceptance patterns align more closely with a continuum of "Visitors" and "Natives" proposed by White and Le Cornu (2011). In this conceptualization, people use technology according to their motivations and context. The Visitors and Natives construct is especially pertinent when considering teachers' and students' motivations for device use in the current study, which differed dramatically in some ways.

Students indicated and demonstrated using one-to-one devices for extensive collaboration and communication with teachers and peers, accessing content, carrying out research, creating for others and for themselves, reaching beyond their peer groups, and completing school work. Students incorporated devices into this process whether or not doing so was required by a teacher. In short, students in the current study suggested practicing the 21st century skill set independently because so many of those skills are inherently supported with a digital device. Teachers, on the other hand, drew a distinction between what they used technology for and what they did not, with all but two viewing it as an option, and sometimes indicating struggles with incorporating it into their classrooms. Thus, for students the question was not whether their classes were supporting 21st century skill development. The question was whether they were developing these skills in a classroom where teachers were supporting device use. A tension exists, therefore, in one-to-one initiative high schools in terms of 21st century skill development in relation to one-to-one initiatives and technology use.

This study also revealed an essential tension between the named goals of one-to-one initiatives—to ensure that students develop 21st century skills while receiving a high-quality education—and meeting the demands of standardized testing and academic accountability. Educators and students recognized the desirability and necessity of skill building—especially in communication and creativity, and consistently tied those skills to important real-world abilities. The more immediate demands of testing for college admission and maintaining a high grade point average, however, have resulted in educational environments that rarely provide high school students involved in one-to-one initiatives with opportunities to build skills aside from study-based skills.

In some situations where teachers embrace teaching with the device, they might substitute typing for paper and pencil writing, or they might use an e-textbook in place of a paper-based textbook but continue to run the classroom as they always have. In classrooms where teachers aspire to new technology-supported approaches, they seem to feel more comfortable with supporting skills as well as stimulating critical thinking around content. However, these approaches are not implemented consistently across classrooms, and teachers' willingness to use ubiquitous devices seems to be based on multiple factors aside from testing requirements (Tusch, 2012). Professional development available through the school, the ability to devote weekends or evenings to skill development, and grade level taught all seem to affect teachers' willingness to support students' 21st century skill development in one-to-one initiatives. More research is needed in this area.

A recent article appearing in *EdWeek* described the digital divide in America's schools, with students from economically disadvantaged schools given fewer opportunities to interact with technology in an academic context than their peers attending schools in wealthier areas (Herold, 2017). The reason, according to the author, had to do with school leadership but also the way in which teachers were taught to use technology. The findings of this study, in contrast, suggest a digital divide within schools based on post-secondary aspirations. Students who identified themselves as bound for higher education and who took advanced placement (AP) courses indicated rich in-class experiences with technology while students who had opted for non-college track courses indicated fewer of those rich experiences or very limited opportunities to use their school devices for skill-supporting tasks. Teachers also noted a difference in students' abilities to use digital devices based on students' post-secondary aspirations. This study, therefore, presents a conundrum in which the students who may benefit most from the enrichment potential of one-to-one initiatives engage in low-level, skill-poor tasks, or they do not make use of the devices at all. While some educators recognized this contrast and strove to address it, others indicated opting to teach these students without the distraction of a device, offering a didactic, digital-free classroom or digitally-supported fill-in-the-blank types of activities requiring low-level cognition. This within-school digital divide warrants future research.

An environment dominated by teacher control, whether enacted online or face-to-face, tends toward being drill heavy instead of skill supportive. Just as a library full of books will not make a town literate if its citizens never learn to read, a one-to-one device will not inspire 21st century skill literacies if students are not taught to use the devices for skill building. When educators fail to support all students in using technology in ways that develop creativity, critical thinking, collaboration, communication, and digital literacy skills, an opportunity for 21st century skill development is lost.

How One-to-One Initiatives Support 21st Century Skill Development

A recent study on one-to-one initiatives and their impact on 21st century skill development found that teachers perceived improvements in critical thinking, communication, collaboration, and creativity as a result of program involvement (Chang, 2016). The findings of this study, especially when qualitative and quantitative analyses are considered together, strongly uphold Chang's (2016) findings. Further, in the current study, students recognized the role of devices in promoting that learning and skill building.

This study strongly suggests that one-to-one initiatives hold the potential to support 21st century skill development and educate for the future. Without a doubt, teachers and students both held a clear and somewhat consistent vision of the future of education. The ability to manipulate (as opposed to just consume) technology played into all descriptions of future schooling, as indicated by questions 10 and 11 in Appendix D and E, respectively. The ideal 21st century skills-supporting school, according to most participants, was one in which fast computers and speedy Internet connections would allow effortless connection with experts within and outside the school community. This ideal school would be cross-curricular and foster real-world educational experiences that would prepare students for the world of work and self-directed studies. The current schooling model, however, whether or not it is supported by one-to-one devices, reflects only limited opportunities for this type of real-world connection.

Although participants indicated that 21st century skill-development can be supported through one-to-one initiatives, that support is not nearly as robust as the future that participants envisioned. Descriptions of communication and content mastery, in particular, were clear, and participants could explain how initiatives support their development. Both communication and content mastery have been fundamental elements of schooling for decades, so it is natural that participants could easily describe these domains. In contrast, three skill areas that stood out as particularly difficult for participants to describe were digital literacy, collaboration, and creativity, potentially due to a lack of a shared understanding or common language around the meaning of these domains of the 21st century skill set. Traditional schooling has not supported these areas strongly, and this lack of focus in these areas might also explain the difficulty.

Curiously, participants' descriptions of digital literacy, when compared to the Partnership for 21st Century Skills (2007) or the International Society for Technology in Education (ISTE) conceptualizations, were very limited. Both ISTE and Battelle for Kids view digital literacy as a multifaceted skill incorporating abilities beyond simply accessing the Internet or turning on a computer. That students struggled to fully define digital literacy begs the philosophical question of whether something can exist if a person cannot articulate the concept in the first place. The resultant survey items only reflect a very limited understanding of digital literacy when compared to organizational standards, which may be a limitation of the study, because items reflect a real rather than idealized 21st century skill set.

Students and teachers in the current study also struggled to describe collaboration in relation to one-to-one initiatives. Due to the potential of devices to support out-of-school and real-world collaboration, this finding was surprising but not unexpected, especially given previous findings that collaboration was not part of students' desired outcomes associated with technology use (Dieterle, 2008; Dieterle, 2009; Fåhræus, 2004). Limitations around pedagogy as it relates to supporting collaboration may account for this finding. While schooling in general in the United States has become increasingly collaborative in recent years, according to the findings of the current study, teachers generally grant insufficient attention to structuring, facilitating, and assessing collaborative learning, leaving students to work out cooperative relationships without guidance (Blatchford, Kutnick, Baines, & Galton, 2003; Ruys, Van Keer, & Aelterman, 2012). In addition to neglecting pedagogy around collaboration, achievement around collaboration is also disregarded in lieu of assessing the content that students should be mastering through collaboration. Students, therefore, do not recognize growing collaboration skills, even though they engage in collaborative activities frequently.

Another reason that students involved in one-to-one initiatives in the current study may have failed to recognize collaboration is related to security. Any Internet-connected device potentially opens to students a world of resources, information, and interactions. The Federal

Communications Commission's (2017) Children's Internet Protection Act (CIPA), however, requires school districts to "block or filter Internet access to pictures that are: (a) obscene; (b) child pornography; or (c) harmful to minors (for computers that are accessed by minors)" (para. 2). Schools that do not take steps to comply with this act could lose the federal funding that helps pay for one-to-one initiatives.

Caught between a desire to maintain federal funding and support collaboration with outside entities, schools must opt to keep students safe by limiting who students can collaborate with through school devices. These protective measures result in a closed loop of collaboration which limits online access to teachers and other students and restricts content that can be shared. Such limitations potentially result in young adults who have not been taught how to conduct themselves in digital interactions in the post-secondary world. Quantitative analyses also reflected low validity of items expressing collaboration, suggesting a need for more research that focuses on collaboration in one-to-one initiative schools.

Students and teachers additionally struggled to agree on a definition of creativity in relation to 21st century skills; however, when asked whether they agreed that digital devices support creativity, 100% of respondents said yes, which reflects the strong findings reported by Chang (2016). Interestingly, however, student definitions of creativity in relation to one-to-one initiatives reflected artsy, academic, and technologically-focused understandings of the skill, which consequently affected perceptions of the degree to which one-to-one devices support creativity. When some students encounter in-school restrictions on Internet access or limitations having to do with time or place, they creatively adapt their use patterns to accommodate their goals. Students' willingness to find ways to bypass security, access data by running cell phone hotspots, pursue independent research when bored in class, or create online spaces to support study groups or share resources all reflect creativity and, therefore, skill development.

This tension also emerged in the quantitative phase of analysis, where items in the creativity domain frequently showed no significant difference of mean perceptions between digital literacy and critical thinking. In addition, many items identified as indicators of creativity factor loaded under other domains. This finding may reflect an evolving understanding of creativity in relation to the affordances of technology and support students' nuanced definitions of creativity.

Like collaboration and creativity, the support offered by one-to-one initiatives for critical thinking development was fairly limited, which is surprising given the fact that nearly all school-based tasks are potentially nested in critical thinking. For example, as students use their devices beyond parameters established by teachers, share documents to collectively complete assignments or review for tests, participate in discussions, grapple with research, or collaborate with peers, they are developing and using critical thinking skills. As with collaboration, students' limited access to online resources via school devices seems to affect their ability to regard the devices as easy conduits for developing critical thinking. Students' perceptions of limited exposure in schools to a variety of opinions also affected their conceptualization of one-to-one initiatives acting as critical-thinking skill builders.

It is important to note that, while students must possess certain skills to carry out the tasks discussed above, support for students developing those skills often came from peers rather than teachers in the current study. In addition, the actual execution of the tasks was accomplished haphazardly outside of teacher support or instruction. Assessments of student success or failure in these endeavors were carried out largely through informal feedback loops between students. These independent projects reflect autonomous learning occurring as a result of one-to-one initiatives but also represent the loss of teacher control that can occur with the introduction of a device into a school setting. While authentic learning seems to result for the students who choose to pursue this skill development outside of teacher direction, students who do not have strong post-secondary academic aspirations may be excluded from this type of learning due to the low-level or non-technology supported lessons in which they participate through school. Although students and teachers were able to describe the extent to which one-to-one devices can support 21st century skills in the current study, actual skill development was conscribed by other factors within the schooling environment, including the inconsistency with which initiatives are embraced across faculty and the curriculum.

Intersections Between Qualitative and Quantitative Findings

Several studies of 21st century skills and the role of technology in supporting those skills have been situated in middle school settings. Literature on the effect of one-to-one initiatives in high school is more limited, resulting in conflicting findings between this study and those conducted with a younger student population. Hodgson (2016), for example, found that all tasks in which students used one-to-one technology contained at least one element of the four Cs (e.g., communication, collaboration, creativity, critical thinking). An older study noted that middle school teachers in one-to-one initiative schools were acting more as facilitators and coaches than directors (Inan, Lowther, Ross, & Strahl, 2010). In the high school setting in the current study, however, students indicated a divergence away from creativity and critical thinking in relation to device use, and frequently described teachers using didactic approaches. Interestingly, students from one school had been involved in a one-to-one initiative in middle school and contrasted their use then (i.e. largely for projects and creative presentations) with device use in their high school (i.e., note-taking and content mastery). This finding would suggest that skill building in one-to-one initiatives may be more prevalent in lower grades than in high school.

A comparison of the quantitative and qualitative analyses of the current study allows a deeper understanding of what may be happening around skill development in one-to-one initiative high schools. When conceptualized as a whole, the items which resulted from the quantitative phase of the study reflect a conceptualization of 21st century skills that is neither neat nor evenly weighted. The skills do not flow easily into one another but instead appear disbalanced, with communication dominating the scale. In addition, communication is heavily emphasized and perhaps over-represented in students' visions of skills for tomorrow, reflecting a today in which social media and one's ability to communicate within that domain is an essential skill, but also reflecting a schooling culture in which traditionally communicative skills (e.g., public speaking, writing, answering teacher questions) receive considerable attention. Collaboration, in comparison, received comparatively little statistical validation in analyses, suggesting the possibility that limited value is placed on this skill in education or that collaboration does not align with qualitative participants' perceptions of skills developed through one-to-one initiatives.

A more careful analysis, however, reveals close interactions between domains. It is difficult, for example, to discuss approaches to problem solving without also borrowing skills from the collaboration and critical thinking domains. Without digital literacy, one cannot create multimedia presentations because of the complexity of executing such a task. It is possible that the 21st century skill domain should not be conceptualized as disparate skills to be mastered in exclusion from one another but an integrated system of skills which are inter-related and dynamic. The findings within each domain help express some of the complexity and interrelatedness of items.

In the communication domain, items on the proposed scale have excellent validity and reliability suggesting that they measure 21st century skills in one-to-one initiative high school. Frequently there was no significant difference of the items expressing communication over collaboration. This finding also fits with the 21st century frameworks, which frequently join the two domains into one. This finding may be due to the observation that activities that are communicative in a one-to-one initiative often require collaboration in the form of group work. In observations, for example, students worked closely to illustrate and prove mathematical theorems. In a civics class, students shared short writings about the Bill of Rights online with the teacher and then discussed their opinions with peers. In an English class, students worked together to refine writing in Google Docs. The teacher's expected outcome in each of these situations was standards-based and content promoting, but students were also refining their communication (through collaboration) for eventual teacher evaluation. By participating in these interactions, students were receiving feedback on the quality of their writing or speaking, which would be graded, but the collaboration perhaps was not seen as a separate skill, possibly explaining why collaboration items performed poorly in statistical analyses.

Content mastery and digital literacy, like communication and collaboration, shared many cross loadings in exploratory factor analysis (EFA) and displayed a lack of significant difference between perceptions of items representing one versus the other. This finding may reflect a shift in accessing content that participants discussed in the focus groups and teacher interviews. In one-to-one initiatives, digital literacy is a fundamental skill for content mastery. As students indicated, teachers supplement content by putting PowerPoint presentations and study guides online to help students study. In cases where teachers do not provide these materials (and even in situations where materials are provided), students indicated working together outside of school hours through group chats or video calls (for example, through Facetime). As students collaborate virtually, they share materials to help one another prepare for testing or complete homework assignments. The lack of a significant difference in means between content mastery and digital literacy, therefore, may be explained by the fact that teachers and students are supporting content mastery through one-to-one initiatives.

In the creativity domain, items frequently showed no significant difference of perceptions between digital literacy or critical thinking on a Games-Howell post hoc test. This finding suggests that, while creativity is well supported by high school one-to-one initiatives, creative activities are complex and involve critical thinking as well as digital literacy, especially when supported by a one-to-one initiative. As noted by one teacher, with the introduction of a one-to-one device, students can be creative in school without being involved in drama, music, or art. The definition of creativity may be undergoing a shift with students responding to growing opportunities for creative expression afforded in digital environments. However, with teachers this definition may not yet have shifted, possibly because creativity goes largely unaddressed on a policy level or in teacher training programs due to limited requirements associated with accreditation (Henriksen et al., 2018).

The finding that teachers had a fairly limited view of creativity in relation to technology was in agreement with a recent New Zealand study on teachers' perceptions of creativity, which discovered that early childhood educators were less inclined to agree that technology was about creativity and more about having students engage in linear processes (Courtney, Lee, McGlashan, Toso, & Neveldsen, 2017). In the qualitative portion of the study, student participants discussed using school devices not only for artistic, creative pursuits but also for technologically creative ones. The items in the creative domain reflect this shift as they describe multimedia presentations and virtual models rather than traditional notions of art (e.g., music, drawing, acting, and painting). The three types of creativity that emerged from the qualitative portion of this study are unique in the literature and warrant additional research.

The items in the critical thinking domain reflect thinking that occurs in both face-to-face and online interactions. These findings discount earlier concerns that introducing digital devices to an educational setting will supplant face-to-face interactions or cause students to devalue personal interactions. Findings in this domain suggest that critical thinking skills are as much about using devices as they are about considering others' perspectives and opinions. An interesting item emerged for potential inclusion on the final instrument—maintaining focus during class. This item suggests that an important skill for students to master as part of the 21st century skill set is knowing when to pay attention. Ubiquitous computing introduces the possibility of constant distraction from classroom instruction, and students in all focus groups touched on the evolution of their abilities to pay attention to a teacher versus play games online. Seniors indicated mastering this skill as sophomores or juniors, suggesting the possibility that this ability is a skill that they developed gradually through their high school careers and justifying its inclusion on this instrument. One-to-one initiatives offer a context in which skills could be developed if teachers involve themselves in such skill building. More research is needed to identify how self-regulation of this kind develops.

Implications and Suggestions for Future Research

This study describes students' and teachers' perceptions of skill development in one-to-one initiative high schools and proposes 31 items to be included in a 21st century skill-measuring instrument. As noted in chapter one, however, the study has some limitations. First, only three high schools participated in the qualitative portion of the study. Face-to-face interviews may have resulted in response bias, and self-expressed perceptions are not always reliable. Convenience sampling of schools may have resulted in over-representation of similar viewpoints.

Data were not collected from administrators or parents, even though both groups are stakeholders in one-to-one initiatives. Collecting interview data from these groups would likely have offered valuable perspectives on the phenomenon at hand. Future research should broaden its focus to develop a more in-depth understanding of perspectives of skill development through one-to-one initiatives. Perspectives contributed by different groups would further confirm or deny the present findings. Despite these limitations, the present study's findings strongly suggest measurable indicators of skill development supported in high school one-to-one initiatives. Below are implications for high schools aiming to support 21st century skill development through one-to-one initiatives.

Measurable Skills

As has been noted previously in the literature, high school one-to-one initiatives hold the potential to support students' 21st century skill development (Collier, 2008; Lowther et al., 2012; Mast Ryan, 2013; Zheng, Warschauer, Lin, & Chang, 2016). In response to this suggestion, this study's primary outcome is an instrument that measures students' 21st century skill development. While the instrument still needs to be pilot tested with a larger cohort, early statistical analyses suggest that proposed items are valid and reliable indicators of 21st century skill development. This finding opens tremendous potential for the field of 21st century skills and one-to-one initiative research.

Once the final piloting stage and factor analysis have been completed, the instrument might be used to collect pre-post data on cohorts' progress in high school one-to-one initiatives.

The resultant data might be used to guide curriculum and professional development. Furthermore, the instrument might be used to help teachers and administrators to better understand 21st century skills in practice. At a school level, the instrument could be a powerful but simple tool for assessing student progress.

At a district level, the instrument can be used in creating accreditation reports and to offer districts another avenue by which they can describe student progress to a public eager to know more about the quality of their schools. Because the instrument diverges strongly from other measures of student achievement, the results reflect a side of education that does not often receive attention. Skills are increasingly emphasized in schools and society, so this instrument provides a window to the skills developed in one-to-one initiative high schools.

Finally, at a general education level, this instrument potentially could supply statistical data on skill-based differences between one-to-one initiative and non-initiative schools. As noted earlier, previous researchers have suggested that skill building occurs in one-to-one initiative schools. However, without a metric it has been impossible to make more definitive statements about differences in skill-building in these two contexts. Given the manageable length of the instrument and the ease with which it might be administered and scored, carrying out a large-scale project to determine statistical differences in skill-building would be a realistic (and exciting) proposition.

Ongoing and Strategic Professional Development…Forever

Professional development is a critical element of successful one-to-one initiatives but is also one of the primary challenges in sustaining such a program (Topper & Lancaster, 2013). This study suggests one-to-one initiative PD must change over time due to the possibility that challenges and benefits in such programs seem to evolve in a set pattern. Initial PD focuses on technical and curricular support but leveraging devices to overhaul instructional practices does not occur over the long term as frequently as non-instructional professional practices (Bebell & Kay, 2010). Bebell and Kay (2010) found that impacts of one-to-one initiatives take years to be fully realized, and the current study, which focused on one-to-one initiative programs that had been in place for between five and almost 20 years, supports this finding.

While countless one-to-one initiative researchers have made recommendations around professional development, the findings of the current study strongly suggest that PD should be tailored to respond to individual programs based not only on characteristics of place but also of time. Specific PD targeted at long-term support for 21st century skill development is warranted in schools that are guided in their implementation by ISTE or Battelle for Kids rhetoric.

Penuel (2006) noted that traditional professional development afforded to teachers in after-school and summer in-service formats may be insufficient for those involved in ubiquitous computing initiatives, and this holds true as well for schools trying to support 21st century skill development through these initiatives. Training should be embedded throughout the school year and devoted to adoption and integration initially. As the initiative becomes more established, the training should change and continue to evolve for as long as the initiative is in place. The general goal of PD in one-to-one initiative schools should consistently be to maximize student benefits around skills, support development, assist with content delivery, and facilitate widespread computer use (Richmond, 2018; Topper & Lancaster, 2013). In contrast, after-school professional development that is not consistent or ongoing, does not garner regular time and attention, fails to leave space for participants to experiment with classroom technologies, and does not address skill development in addition to technology exploration will become a barrier to the ongoing success of the one-to-one initiative in general and in supporting the 21st century skill set.

To the best of the researcher's knowledge, no studies have focused on quantifying an ideal number of hours to devote to technology-related professional development or the ideal frequency with which professional development should be held in one-to-one initiative schools. Additionally, no studies have elucidated an empirically determined, ideal course of professional development for one-to-one initiative schools. Further research is needed to guide administrators and teachers in setting long-term, multi-year professional development schedules that respond to one-to-one initiative support as well as 21st century skill development. Additionally, a comparative study of the effects of monthly versus quarterly trainings (for example) might yield results that could guide educational leaders in providing appropriate and effective professional development opportunities to one-to-one initiative schools. Finally, studies of professional development in one-to-one initiatives tend to focus on relatively new programs and the nuts and bolts of implementation; however, given the age of some initiatives in the United States (i.e. some programs are nearly 20 years old), it would be helpful for future research to focus on qualities and effects of specific long-term professional development that focuses on one-to-one initiatives.

Helping Students Negotiate the 21st Century Skill Domain

In a 2017 study of one-to-one initiative schools worldwide, the researchers focused extensively on students' patterns of computer use and recommended that teachers acknowledge the reality of students' computer use habits (Blikstad-Balas & Davies, 2017). The researchers recommended that teachers demonstrate a "readiness to teach [teens] how to make good use or and good judgements about their participation in the online world, rather than leaving them to learn about these things of their own" (Blikstad-Balas & Davies, 2017, p. 328). Similarly, the findings of the present study strongly suggest that teachers need to abandon the idea that when it comes to technology they have nothing to offer students.

When classroom technology is paired with expectations of skill development, teachers can play a key role in supporting students' academic and non-academic progress. In classrooms where teachers justify their non-use of technology through generational stereotypes (e.g., "Teens just know what to do with computers; there is very little I can teach them when it comes to technology."), 21st century skills get short shrift. When teachers disengage from guiding their students in their interactions with technology, or when teachers mandate that students put away the devices during class, students gain little other than a false sense that they already possess the skills they need for future success in the invariably complex interactions with technology. One-to-one initiative teachers, therefore, need to recognize ways that they can support students in understanding and developing 21st century skills in relation to and in the absence of technology.

A second recommendation related to helping students negotiate the 21st century skill domains is to recognize the relationship between those domains and students' lives. In the current study's qualitative and quantitative phases, applying attention to classroom proceedings emerged as an important skill to be developed through one-to-one initiatives, suggesting that students recognize that this area needs nurturing and attention to develop. Teachers may already support 21st century skill development in face-to-face relationships, but current findings strongly suggest that equivalent skill development is needed in one-to-one initiatives, especially in consideration of the finding that students conceptualized creativity in relation to some of the digital world's riskier propositions (e.g., hacking and manipulating online security systems). Teachers must transform beliefs about their role in skill building and technologically-assisted learning for the future before one-to-one initiatives can transform the educational landscape.

Also important is that teachers develop a clear understanding of the purpose of school device use. If that purpose has not been clearly articulated to teaching personnel and, consequently, to students involved in the initiative, skill development may falter. In a related manner, the purpose of implementing and supporting a one-to-one initiative must regularly be revisited and reformulated as the initiative evolves. In the studied schools, devices were said to be in place for reasons that varied from supporting the established curriculum to improving learning to making a statement to stakeholders. All these reasons were out of sync with the official aim of the devices—to support 21st century skill development. Clarity of vision may contribute to demystifying the intent of an initiative while also promoting common verbiage, resulting in institutionally shared language and, ultimately, student benefits.

Understanding and Responding to the Limitations of One-to-One Devices

In 2013 on his learning blog, Alan November advocated for schools moving beyond the conceptualization of one-to-one initiatives as being one student to one device. Instead, he argued schools should envision their initiatives as holding the potential to link students to the world. According to November (2013), a more appropriate name would be “one-to-world” (para. 9). Given the limitation imposed by federal regulations, November’s vision of limitless access to the world’s resources is not realistic in its entirety. The findings of the current study, however, have led to recommendations that would support students in developing skills to facilitate a one-to-world relationship on their own.

As is well known, putting a device in the hands of every teacher and student is not enough to stimulate educational transformation or skill building. Essentially a digital device is a tool, and discussion of improvement in one-to-one initiative schools must focus less on the device and more on the skills being supported through the device. Simply put, computers cannot do it all and, as students noted consistently throughout data collection, teachers are essential to students' successful learning in one-to-one initiatives. Similarly, teachers and administrators advocating for 21st century skill development without clearly articulating the meaning, vision, and rationale for students developing that skill will result in little or no skill development. To encourage and support 21st century skills, leaders must be 21st century skill masters and demonstrate collaboration, communication, and critical thinking to colleagues and the student body.

Alan November in the aforementioned blog post (2013) advocated strongly for adopting a 21st century skill mindset by shifting the culture of learning within a school, deemphasizing the what of learning and replacing it with the how. The findings of this study, however, suggest that focusing on "the how" at the expense of "the what" disadvantages students because their understanding of the 21st century skill set includes content mastery assisted by device use. Teachers are in the classroom without a doubt to promote skills for the future, but the reality of education is that there is a body of knowledge young people must master to become informed citizens of the world. To tell students and teachers otherwise is a disservice as not only do formal institutions require demonstration of this knowledge, but so does adult society. One role of education, therefore, is to impart this knowledge, and content mastery can and should be supported within one-to-one initiative schools. The human element in that equation, however, is essential. Devices alone can do nothing transformative or skill developing without structures in place to support learning that supersedes a model of tech consumption and paper-pencil substitution. The device, however, is not what brings about this change—clearly articulated vision and leadership that models and empowers brings that change.

Conclusion

Incorporating ubiquitous technologies into high school settings has led to a conundrum, where students are simultaneously engaged in learning and distracted from it. At the same time, the American educational system is struggling through a reconceptualization of its identity, trying to determine whether the system will promote educational outcomes for the short term (i.e. academic gains) or learning that might prepare students for the world of tomorrow (i.e. skills). Capitalizing on this identity crisis, educational pundits as discussed in Chapter One have criticized America's educational institutions, arguing that the system is trapped in a model that mimics the system of 100 years ago (Cuban, 2012; November, 2010). Scholars have written, however, about the potential for one-to-one initiatives to simultaneously educate for now and prepare students for an unknown future with skills appropriate for the post-secondary world, effectively transforming education (Abell Foundation, 2008; Baines & Romano, 2015; James-Burdumy et al., 2009; Slavin et al., 2009; Zheng et al., 2016). The key is for stakeholders to recognize that technology alone is not the answer to bridging the distance between the needs of today and tomorrow. Sustained and ongoing professional development devoted to the ever-changing demands of one-to-one initiative learning; a dedication to 21st century skills development; and a shared, well communicated, and constantly revisited vision of the initiative all contribute to an initiative's success.

This study plays a very small part in promoting better understanding of high school one-to-one initiatives. First, in the context of the history of school-based computing initiatives, this study acts as a marker in the timeline of studies describing computer use patterns in teachers and students. In the realm of activity theory, this study highlights tensions that exist and have evolved in one-to-one initiative high schools. In relation to 21st century skill development, this study makes the largest contribution. As of writing, a simple tool to measure skill development is unavailable. This study addresses that gap.

Despite the promise of one-to-one initiatives to respond to the future while also supporting learning for today, there has been an onslaught in recent years of stories of beleaguered school districts dropping their one-to-one initiatives (Lapowsky, 2015). These failures, which are generally widely touted in the media, somehow confirm the suspicion that school and technology are incompatible, and that computers remain distractions rather than promoters of powerful learning. Quantitative findings in the current study, however, suggest that these assumptions may be largely incorrect, and that skill building can occur in tandem with content mastery at the hands of able and well-supported educators. Further, findings suggest that one-to-one computing initiatives are powerful tools for encouraging 21st skill development, but such skill development is not a natural outgrowth of one-to-one initiatives.

During student focus groups interviews, participants several times alluded to the value they place on their district's one-to-one initiative, describing their involvement as transformative, skill building, and preparatory for the future. In the school with the oldest initiative, students advocated strongly for their one-to-one initiative to remain in place, as if they feared the current research potentially would contribute to defunding the program. They described the importance of a one-to-one initiative not only for themselves but also for skill building in younger students in the district. With the exception of a few students in the private school, all students spoke passionately about their one-to-one initiative involvement, tying it to a feeling of connectedness and support from teachers and other students and describing the rich communication and collaboration fostered through their school devices. Students also spoke of a feeling of "one-upping" their future workmates and college classmates who would possibly come from schools without ubiquitous technology initiatives.

Teachers expressed a wider spectrum of enthusiasm, varying from almost complete refusal to incorporate any technology in their classrooms to mono-use of the device (e.g., only using it for in-class quizzes) to unabashed enthusiasm for incorporating technology into all aspects of the classroom. The former led to discussions of distracted learners, the devaluation of teachers, and the importance of relationships. The latter, in contrast, led to constant experimentation and professional development around the devices as well as leadership roles bestowed by peers and school administrators.

Referring to technology use in the business world, Jim Collins (2001) observed, "Technology alone never holds the key to success…but…when used right, technology is an essential driver in accelerating forward momentum" (p. 159). With this perspective in mind, it is imperative that teachers and administrators regularly evaluate what forward momentum looks like. At this moment, forward momentum seems to look like 21st century skill development. This study's participants (even in the school with the oldest initiative) expressed a hope that schools with ubiquitous computing initiatives continue to improve implementation. In doing so, students not only *learn about* the world but also develop skills so that they can *be* more effectively in the world. Students will always need teachers who inspire them to think, who show they care, who make personal connections, and who find ways to connect learning to students' lives. Increasingly, however, students also need teachers who model digital and face-to-face communication in what feels like an increasingly connected and contentious world, support students in learning how to collaborate, create opportunities for critical thinking, and present opportunities for innovation. Stakeholders must remain sensitive to the nuances of new literacies, including digital literacy and, using all these skills, support students' pursuit of content mastery.

The study’s findings suggest that these skills may be quantifiable and, at least at this moment in time, represented by abilities to carry out certain tasks or hold certain mindsets. To prepare excellent students for an unknown future, schools must ensure that our educational focus is constantly evolving. Supporting 21st century skill development with one-to-one initiative-mediated learning can assist with that forward momentum.

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APPENDICES

Appendix A

Letter of Consent for Teacher Interviews

Title: Exploring the Dimensions of 21st Century Skills in High School-Based One-to-One Initiatives: Creating and Validating a Scale Using Mixed Methods Research

Principal Investigator: Rachel Schiera, D.Ed. candidate, Education

Faculty Advisor: Dr. Sue Rieg, Professor, College of Education and Educational Technology; (724) 357-2485; Stouffer 104, Indiana University of Pennsylvania, Indiana, PA 15701

My name is Rachel Schiera. I am a doctoral student in the Department of Professional Studies in Education at Indiana University of Pennsylvania. I am currently conducting a study on high school students' and teachers' perceptions of the 21^{st} century skills that students develop in one-to-one device initiatives. This information is being provided to you so you can make an informed decision to participate or not.

You have been asked to participate in this study because you teach as part of a one-to-one device initiative. The current study has been designed to develop a better understanding of the skills that high school students develop in schools with laptop programs. Upon completion of this study, I expect to create an instrument that measures students' skill development in relation to laptop computer use in school.

Upon you giving consent to participate in the study, I would like to observe a class of your choosing using the H.E.A.T. Protocol to guide that observation and then ask you ten post-observation interview questions. I will record those answers with a digital voice recorder as well as a back-up device. The interview will take about 20 minutes of your time and can be done at a place and time that is convenient for you.

If you give consent to participate in this study, your name or personal identifiers will not be disclosed to anyone except me, the researcher. If I use information from your interview for any purpose, a pseudonym will be used for your name and personal identifiers will be obscured to all extents possible. After transcribing the interview and completing the interview protocol, I will share the documents with you. At that point, you can read the transcript to confirm that there are no errors and contact me with concerns. At any point, you can access the study website to access information on its progress.

No risk beyond the minimal risks of daily living will be involved, and you will not be compensated for participating. Your participation in this study is voluntary, and you are free to choose if you want to participate in this study or not participate, and you can withdraw at any point during the study by indicating that you wish to discontinue participation. If you or choose to withdraw from the study, all of your information will be destroyed. If you volunteer to participate, all of your responses will be anonymous and your identity will be kept confidential.

Any physical data collected in this study will be kept in a locked file cabinet that can be accessed only by the researcher, and the digital data will be kept in a password protected hard disk. When the study is finished, the study results may be presented at conferences and/or published in academic journals. If information is presented at conferences and/or published in academic journals, only fictional names of participants will be used. The information will only be used for academic purposes.

Statement of Consent

I understand the information on this consent form and agree to volunteer to be a subject in this study. I understand that my identity will be anonymized and that I have the right to withdraw from the study at any time. I have received an unsigned copy of this informed consent form to keep in my possession.

Participant's Name (PLEASE PRINT) Participant's Signature Date

______________________________ _________________________________ _______

Phone number or location where you can be reached Best days and times to reach you

______________________________________ __________________________________

I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participating in this research study, have answered any questions that have been raised, and have witnessed the above signatures.

____

Date Investigator's Signature

Project Director: Rachel Schiera, Doctoral Candidate
Professional Studies in Education, Davis Hall
Indiana, PA 15705
Phone: 410-253-9130

This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724/357-7730).

Appendix B

Letter of Assent for Students

Title: Exploring the Dimensions of 21st Century Skills in High School-Based One-to-One Initiatives: Creating and Validating a Scale Using Mixed Methods Research

Principal Investigator: Rachel Schiera, D.Ed. candidate, Education

Faculty Advisor: Dr. Sue Rieg, Professor, College of Education and Educational Technology; (724) 357-2485; Stouffer 104, Indiana University of Pennsylvania, Indiana, PA 15701

I would like you to help me with a research study. This letter should help you decide to help me or not help me with this study. It is fine for you to ask me questions while I'm explaining my study to you. I would like you to help me because you are a high school student involved in a laptop program.

I would like to know students' perceptions of the benefits of laptop initiatives. Helping me with this study will take about one hour of your time. If you would like to help me, I will ask you to participate in a discussion group of about six people. During the discussion, I will ask the group some questions about the ways that laptops are useful to you in school. Then I will ask you about choices others have made.

While we are talking, I will be making a video and audio recording of our conversation so I can remember it when I write up the study. However, the camera will be positioned in such a way that no one will be able to see your face in the recording. I will only use the video recording as a backup in case the audio recording's sound is not clear or I need a reminder about the physical characteristics of the room or the group's interactions.

There are no known risks associated with the study, and you will not be compensated in any way. However, the things I will learn from talking to you will help me to create a way to measure the types of skills students might be developing through laptop programs. I promise not to be rude or trick you in any way when we are talking, and you should feel comfortable at all times. You can tell me at any time if you are feeling uncomfortable with the direction our conversation might be taking.

No one is making you talk to me, and you don't have to if you don't want to. It is okay if you don't want to share your experiences with me. If you decide later that you don't want to be part of my research study, you can tell me that by calling, emailing, or writing to me, and I will put the information I have collected from you into the garbage and not include it in my study.

If you do want to be in my study, nobody will know who you really are. You can pick a different name to use or I will pick one. As I am talking about laptop program with a lot of people in the United States, our talk together will be a little part of the big study. When I finish my research study, I might talk about what I learned with other people or write it down so other people can read it, but I will always use your fake name as your secret identity. You can look at the study's progress at any time on the study website, too, but I will not use your real name there, either.

If you would like to help me in my study, please sign at the bottom of this sheet. I have a copy of this form to give to you to keep, as well as one for your parent/guardian. If you don't want to help me in my study, do not sign this sheet.

(Please continue to back of page.)

I, ________________________________, want to be in this research study.

________________________________ (Sign your name here)   ________________ (Date)

Project Director: Rachel Schiera, Doctoral Candidate
Professional Studies in Education, Davis Hall
Indiana, PA 15705
Phone: 410-253-9130

This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724/357-7730).

Appendix C

Parent/Guardian Consent Form

Title: Exploring the Dimensions of 21st Century Skills in High School-Based One-to-One Initiatives: Creating and Validating a Scale Using Mixed Methods Research

Principal Investigator: Rachel Schiera, D.Ed. candidate, Education

Faculty Advisor: Dr. Sue Rieg, Professor, College of Education and Educational Technology; (724) 357-2485; Stouffer 104, Indiana University of Pennsylvania, Indiana, PA 15701

My name is Rachel Schiera. I am a doctoral student in the Department of Professional Studies in Education at Indiana University of Pennsylvania. I am currently conducting a study on high school students' perceptions of the skills that laptop computers develop. As your child has been invited to participate in the study, this information is being provided to you so you can make an informed decision to allow your child to participate or not.

Your child has been asked to participate in this study because he or she was given a laptop as part of a one-to-one device initiative. The current study has been designed to develop a better understanding of the skills that high school students develop in schools with laptop programs. Upon completion of this study, I expect to create an instrument that measures students' skill development in relation to laptop computer use in school.

Upon you giving consent and your child giving assent to participate in the study, I will ask your child to participate in a discussion along with no more than eight peers on skills developed while participating in a laptop initiative. I will ask about ten questions and related follow-up questions and record those answers with a digital voice recorder. I will also make a video recording of the discussion but will position the camera so that no student can be identified. The discussion group will take about an hour of your student's time.

If you give consent for your child to participate in this study, your child's name or personal identifiers will not be disclosed to anyone except me, the researcher. If I use information from your child's interview, a pseudonym will be used for your child's name; I will not disclose to anyone your child's name.

No risk beyond the minimal risks of daily living will be involved, and your child will not be compensated for participating. Your child's participation in this study is voluntary, and you are free to choose if you want your child to participate in this study or not participate, and you or your child can withdraw at any point during the study by indicating that you wish to discontinue participation. If you or your child choose to withdraw from the study, all of your child's and your information will be destroyed. If you volunteer to participate, all of your child's responses will be anonymous and his or her identity will be kept confidential.

Any physical data collected in this study will be kept in a locked file cabinet that can be accessed only by the researcher, and the digital data will be kept in a password protected hard disk. When the study is finished, the study results may be presented at conferences and/or published in academic journals. If information is presented at conferences and/or published in academic journals, only fictional names of participants will be used. The information will only be used for academic purposes.

Child's Name (PLEASE PRINT)

____

Parent's/Guardian's Name (PLEASE PRINT)

____

Parent/Guardian Signature

____

Date

Phone number or location where you can be reached

Best days and times to reach you

I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participating in this research study, have answered any questions that have been raised, and have witnessed the above signatures.

____

Date Investigator's Signature

Project Director: Rachel Schiera, Doctoral Candidate
Professional Studies in Education, Davis Hall
Indiana, PA 15705
Phone: 410-253-9130

<u>This project has been approved by the Indiana University of Pennsylvania Institutional Review Board for the Protection of Human Subjects (Phone: 724/357-7730).</u>

Appendix D

Student Focus Group Interview Protocol

1. In the description of this study, I will use words like communication, collaboration, ICT literacy, and creativity. What do these words mean to you?
2. I am going to say two sentences. “High school in a school like mine is about gaining knowledge” and “High school in a school like mine is about developing skills”. Which statement seems more accurate? Could you explain your thinking?
3. Do you think that having a [school device] has changed your teachers’ focus? In what ways?
4. Are there school policies or rules that offer support to your use of [school device]? Could you give some examples?
5. In what ways do people at your school use their [school device] to make school a more creative place? In what ways does your [school device] not support creativity?
6. Think of a task that you use your device for a lot in school. How does using your [school device] for that task help you to learn to communicate?
   a. How does using your [school device] help you to learn to collaborate?
   b. How does using your [school device] help you to use technology better?
   c. How does using your [school device] help you to think more creatively?
   d. How does your device help support learning things that you will be tested on?
   e. Is there anything that your [school device] is used for that I did not ask about?
7. What do you think is the biggest barrier to learning how to communicate/collaborate/ think more creatively?
8. Let’s pretend that you are in a class and you run across information that seems doubtful. What would you do? (Is this the same approach you would take if you did

9. How much do you agree with this idea—"I believe I will be well prepared for the future because of how I am learning to use my [school device]."
10. Imagine you were to suddenly transfer into a new school with the motto, "We prepare students with all of the skills for the world of tomorrow". What would you expect that place to look like? What would you expect that place to do?

Appendix E

Teacher Interview Protocol

1. How was students' behavior during the observed lesson, ranging from much better than usual to much worse than usual?

    a. Why do you think the lesson went as it did?

2. In my study, I use words like communication, collaboration, ICT literacy, and creativity. What do these words mean to you?

3. I am going to say two sentences. "High school is about gaining knowledge" and "High school is about developing skills".

    a. Which statement seems more accurate?

    b. Could you explain your thinking?

4. Have [school devices] changed the way that you teach or the way that you approach the classroom?

    a. How so?

    b. If not, why not?

5. Are there specific policies or rules that offer support your use of [school device]?

    a. Could you give some examples?

    b. Are there policies or rules that act as barriers?

    c. Could you give some examples?

6. Some critics say that [school device] cannot be used enhance students' creativity.

    a. Do you agree with this statement?

    b. Could you give some examples from your own practice to support your

7. I am going to share a list with you. How often would you say the observed lesson supported each?

a. Learning to communicate well between students
b. Learning to communicate well between teacher and students
c. Learning to collaborate between students
d. Learning to collaborate between teacher and students
e. Opportunities for students to grapple with new information
f. Opportunities for students to learn to self-monitor while interacting with technology.
g. Learning to be a more creative individual
h. Learning to innovate solutions to real world problems
i. Learning target content
j. Building academic skills
k. Are there other objectives during the lesson that I did not cover or that you think were important to the lesson?

8. What do you think is the biggest challenge in teaching students how to communicate/collaborate/think more creatively?

a. What might help you in overcoming that barrier?

9. What approaches do you take to teaching students to deal with information?

10. To what extent do you agree with the following statement—"As a result of how I am using [school device] in my class, I believe my students will be well prepared for the future."

11. Imagine you are designing the ultimate 21st century skill-building classroom. What

Appendix F

Modified Observation Protocol Checklist

Collaboration	Communication	Creativity	Digital Literacy	Device Use
Students ☐ Ss sit in configurations that allow group work to occur ☐ Ss work in groups with teacher-defined roles ☐ Ss work in groups toward teacher-defined outcomes ☐ Ss organize collaborative groups and roles within group ☐ Ss choose the digital tools they will use in their groups ☐ Ss independently use (or independently indicate the intention to use) digital tools to collaborate across time and space	***Students*** ☐ Ss communicate primarily with Tchr to comprehend material ☐ Ss communicate digitally and/or face-to-face to complete assignments ☐ Ss select from teacher-provided digital communication tools to complete assignments ☐ Ss use digital tools appropriately to communicate ☐ Ss communicate (or indicate the intention to communicate) across time and space	***Students*** ☐ Ss work on products following Tchr directions ☐ Ss have limited opportunities for creativity. ☐ Ss question, summarize, make predictions re existing knowledge ☐ **Ss** use computers to help with the creative process. ☐ Ss create original work, remaining within assignment parameters. ☐ Ss synthesize existing ideas and knowledge to create new products beyond assignment	***Students*** ☐ Ss acquire information/ respond to prompts under direct instruction of Tchr ☐ Ss follow Tchr directions, use provided resources, and apply techniques ☐ Ss select appropriate digital tools ☐ Ss design questions to guide online research ☐ Ss independently choose and use online tools ☐ Ss access, synthesize, and display information related to independent research	***Students*** ☐ Ss act as "audience members", observing Tchrs' use of computers. ☐ Ss follow Tchr instructions in using computers in a conventional manner. ☐ Ss determine the limits of laptop use to complete tasks ☐ Ss independently direct laptop use ☐ Ss go beyond (or indicate the intention to do so) the parameters of classroom requirements of time and space
Teachers ☐ Tchrs provide assignments ☐ Tchrs provide direct instruction that provides opportunities for Ss to work in groups. ☐ Tchrs design challenges to teach Ss collaboration ☐ Tchrs provide instruction that requires collaboration in and beyond the classroom. ☐ Tchrs engage Ss in meaningful, self-directed collaboration ☐ Tchrs assist with constructive skill-based feedback	***Teachers*** ☐ Tchrs direct communication ☐ Tchrs define the limits of communication for Ss work ☐ Tchrs model the use of various communication tools ☐ Tchrs facilitate the use of communication tools ☐ Tchrs facilitate tasks where Ss engage in meaningful, self-directed communication ☐ Tchrs assist with constructive skill-based feedback	***Teachers*** ☐ Tchrs direct classroom proceedings ☐ Tchrs limit students' contributions ☐ Tchrs direct connections between content and new ideas ☐ Tchrs model creativity and innovation ☐ Tchrs design opportunities for Ss to exercise creativity authentically. ☐ Tchrs facilitate an environment where Ss create and innovate. ☐ Tchrs assist with constructive skill-based feedback	***Teachers*** ☐ Tchrs provide pre-selected resources, research questions, and/or topics. ☐ Tchrs instruct directly on online searches, analyzing information, and/or accuracy of sources. ☐ Tchrs model strategies for negotiating digital information. ☐ Tchrs design computer-supported tasks to support Ss' ICT literacy. ☐ Tchrs facilitate Ss engagement with research ☐ Tchrs assist with constructive skill-based feedback	***Teachers*** ☐ Tchrs use classroom computers demonstratively. ☐ Tchrs define the limits of laptop use to complete assignments. ☐ Tchrs demonstrate ways to integrate laptops ☐ Tchrs model the use of various approaches on the laptop. ☐ Tchrs provide Ss with a checklist/guide with numerous avenues to computer use ☐ Tchrs facilitate Ss appropriate engagement with laptops and content

Appendix G

Descriptive Statistics and Analysis of Variance (ANOVA) Results

No.	Item	Mean	SD	*F*-value	*P*-value
1	**Solving problems encountered in the digital world (blocked websites, password protected domains, etc.).**			6.976	.000
	Communication	3.17	1.355		
	Collaboration	3.30	1.102		
	Critical Thinking	3.92	.997		
	Digital literacy	4.15	.907		
	Creativity	3.66	1.159		
	Content Mastery	3.21	1.183		
2	**Assessing online information for reliability.**			9.187	.000
	Communication	3.08	1.357		
	Collaboration	3.26	1.258		
	Critical Thinking	3.74	1.195		
	Digital literacy	4.32	.754		
	Creativity	3.08	1.253		
	Content Mastery	3.70	1.085		
3	**Using a digital device for real-world tasks.**			5.257	.000
	Communication	3.11	1.396		
	Collaboration	3.43	1.294		
	Critical Thinking	3.53	1.170		
	Digital literacy	4.25	.806		
	Creativity	3.68	1.105		
	Content Mastery	3.60	1.230		
4	**Receiving feedback from schoolmates (face-to-face and through digital platforms) on school assignments.**			11.924	.000
	Communication	4.38	.860		
	Collaboration	4.40	.689		
	Critical Thinking	3.51	1.120		
	Digital literacy	3.58	1.117		
	Creativity	3.19	1.429		
	Content Mastery	3.45	1.084		
5	**Generating engaging multimedia presentations.**			8.460	.000
	Communication	3.91	1.061		
	Collaboration	3.74	1.059		

	Critical Thinking	3.75	.998		
	Digital Literacy	4.40	.743		
	Creativity	4.53	.696		
	Content Mastery	3.57	1.201		
6	**Discussing (face-to-face and through digital platforms) research findings with teachers and other students.**			6.917	.000
	Communication	4.40	.947		
	Collaboration	4.36	.811		
	Critical Thinking	3.85	1.026		
	Digital literacy	3.77	1.154		
	Creativity	3.45	1.280		
	Content Mastery	3.64	1.111		
7	**Asking questions of teachers and other students outside of class time through email or discussion boards.**			6.812	.000
	Communication	4.40	.793		
	Collaboration	4.38	.790		
	Critical Thinking	3.62	1.244		
	Digital literacy	3.81	1.161		
	Creativity	3.47	1.339		
	Content Mastery	3.79	1.044		
8	**Using a digital platform to plan extracurricular activities in conjunction with teachers and other students.**			5.896	.000
	Communication	4.13	.962		
	Collaboration	4.21	.863		
	Critical Thinking	3.47	1.120		
	Digital literacy	4.04	.980		
	Creativity	4.04	1.143		
	Content Mastery	3.40	1.230		
9	**Finding consensus.**			3.563	.004
	Communication	3.49	1.031		
	Collaboration	3.77	1.068		
	Critical Thinking	3.57	.910		
	Digital literacy	3.25	1.090		
	Creativity	3.02	1.047		
	Content Mastery	3.26	1.077		
10	**Applying what's been learned in class to real-world situations.**			8.320	.000
	Communication	3.38	1.319		
	Collaboration	3.34	1.208		
	Critical Thinking	4.11	.974		
	Digital literacy	3.15	1.262		

	Creativity	3.94	.989		
	Content Mastery	4.15	.818		
11	**Independently dealing with questionable or doubtful information.**			9.468	.000
	Communication	3.96	1.018		
	Collaboration	3.66	1.143		
	Critical Thinking	3.13	1.210		
	Digital literacy	3.91	.861		
	Creativity	2.92	1.284		
	Content Mastery	2.87	1.415		
12	**Developing digital models to represent concepts studied**.			10.973	.000
	Communication	3.04	1.386		
	Collaboration	3.13	1.272		
	Critical Thinking	3.79	.988		
	Digital literacy	4.00	.855		
	Creativity	4.23	.869		
	Content Mastery	3.87	.856		
13	**Discussing (face-to-face and through digital platforms) approaches to problem solving.**			7.043	.000
	Communication	4.11	.934		
	Collaboration	4.34	.758		
	Critical Thinking	3.94	.908		
	Digital literacy	3.43	1.152		
	Creativity	3.49	1.187		
	Content Mastery	3.58	1.082		
14	**Engineering new ways to do things online (redesigning hardware, programming, coding, etc.).**			8.096	.000
	Communication	3.34	1.315		
	Collaboration	3.32	1.341		
	Critical Thinking	3.87	1.075		
	Digital literacy	4.11	.824		
	Creativity	4.40	.793		
	Content Mastery	3.72	1.063		
15	**Effectively negotiating media sources (e.g. recognize bias, choose appropriate online sources, use keywords, etc.).**			5.815	.000
	Communication	3.53	1.234		
	Collaboration	3.28	1.292		
	Critical Thinking	3.92	.937		
	Digital literacy	4.30	.749		
	Creativity	3.68	1.015		

	Content Mastery	3.55	1.153		
16	**Engaging deeply and thoughtfully with information encountered online.**			5.497	.000
	Communication	3.45	1.294		
	Collaboration	3.28	1.246		
	Critical Thinking	3.96	1.037		
	Digital literacy	4.17	.727		
	Creativity	3.47	1.154		
	Content Mastery	3.89	.954		
17	**Working through conflict within groups of classmates.**			14.639	.000
	Communication	4.32	.976		
	Collaboration	4.28	.948		
	Critical Thinking	3.96	.999		
	Digital literacy	3.04	1.143		
	Creativity	3.15	1.215		
	Content Mastery	3.32	1.283		
18	**Using information or digital technologies to understand school-related material better.**			5.781	.000
	Communication	3.36	1.287		
	Collaboration	3.21	1.276		
	Critical Thinking	3.77	1.050		
	Digital literacy	4.15	.886		
	Creativity	3.62	.985		
	Content Mastery	3.94	.886		
19	**Using online resources to develop wider perspectives.**			5.807	.000
	Communication	3.42	1.167		
	Collaboration	3.34	1.239		
	Critical Thinking	3.94	1.027		
	Digital literacy	4.25	.875		
	Creativity	3.51	1.137		
	Content Mastery	3.89	.974		
20	**Using information encountered online to consider opinions and perspectives from multiple angles.**			4.870	.000
	Communication	3.53	1.234		
	Collaboration	3.55	1.202		
	Critical Thinking	4.19	.833		
	Digital literacy	4.21	.793		
	Creativity	3.62	1.060		
	Content Mastery	3.75	.979		
21	**Innovating products beyond teacher-defined parameters.**			4.389	.001

	Communication	3.11	1.251		
	Collaboration	3.21	1.215		
	Critical Thinking	3.87	1.177		
	Digital literacy	3.38	1.078		
	Creativity	3.89	1.050		
	Content Mastery	3.43	1.047		
22	**Staying focused on what teachers teach during class.**			2.712	.020
	Communication	3.34	1.270		
	Collaboration	3.17	1.267		
	Critical Thinking	3.23	1.235		
	Digital literacy	2.96	1.270		
	Creativity	3.02	1.293		
	Content Mastery	3.74	1.022		
23	**Working together with classmates (face-to-face and in digital environments) on graded assignments.**			9.214	.000
	Communication	4.36	.922		
	Collaboration	4.53	.608		
	Critical Thinking	3.66	1.126		
	Digital literacy	3.55	1.186		
	Creativity	3.77	1.120		
	Content Mastery	3.55	1.119		
24	**Choosing appropriate websites to help with learning.**			8.810	.000
	Communication	3.08	1.357		
	Collaboration	3.15	1.199		
	Critical Thinking`````	3.74	1.112		
	Digital literacy	4.30	.799		
	Creativity	3.53	1.234		
	Content Mastery	3.83	.935		
25	**Using email or discussion boards to contact teachers outside of school hours.**			5.832	.000
	Communication	4.19	.921		
	Collaboration	4.25	.875		
	Critical Thinking	3.49	1.353		
	Digital literacy	3.91	1.061		
	Creativity	3.43	1.217		
	Content Mastery	3.43	1.352		
26	**Arranging and carrying out tasks that require group work.**			7.652	.000
	Communication	4.08	1.071		
	Collaboration	4.40	.793		
	Critical Thinking	3.60	1.115		

	Digital literacy	3.15	1.321		
	Creativity	3.72	1.133		
	Content Mastery	3.68	1.221		
27	**Working together with classmates (face-to-face and in digital environments) on extracurricular projects/assignments.**			10.489	.000
	Communication	4.51	.775		
	Collaboration	4.49	.639		
	Critical Thinking	3.77	1.050		
	Digital literacy	3.60	1.246		
	Creativity	3.74	1.077		
	Content Mastery	3.45	1.234		
28	**Using online resources to carry out research.**			7.426	.000
	Communication	3.23	1.396		
	Collaboration	3.15	1.262		
	Critical Thinking	3.62	1.113		
	Digital literacy	4.28	.818		
	Creativity	3.47	1.137		
	Content Mastery	3.89	1.013		
29	**Asking relevant questions during class.**			4.487	.001
	Communication	3.98	1.028		
	Collaboration	3.70	.992		
	Critical Thinking	3.85	1.008		
	Digital literacy	3.13	1.225		
	Creativity	3.43	1.264		
	Content Mastery	3.85	1.008		
30	**Being able to find websites to make classroom content more meaningful.**			6.175	.000
	Communication	3.25	1.314		
	Collaboration	3.25	1.285		
	Critical Thinking	3.83	.871		
	Digital literacy	4.13	.900		
	Creativity	3.62	1.023		
	Content Mastery	3.91	.883		
31	**Mustering self-motivation to be interested in what is being covered in class.**			2.302	.045
	Communication	3.06	1.307		
	Collaboration	3.08	1.190		
	Critical Thinking	3.53	1.103		
	Digital literacy	3.11	1.354		
	Creativity	3.28	1.199		
	Content Mastery	3.64	1.002		

32	**Giving feedback to peers (face-to-face and through digital platforms) on school assignments.**			9.444	.000
	Communication	4.38	.790		
	Collaboration	4.45	.667		
	Critical Thinking	3.79	.968		
	Digital literacy	3.70	1.119		
	Creativity	3.53	1.250		
	Content Mastery	3.53	.992		
33	**Participating in class-related discussion boards to learn more about what others think.**			6.713	.000
	Communication	4.45	.774		
	Collaboration	4.49	.697		
	Critical Thinking	4.09	.741		
	Digital literacy	3.81	1.210		
	Creativity	3.68	1.156		
	Content Mastery	3.91	.986		
34	**Finding websites that help make studied content more understandable.**			9.963	.000
	Communication	3.09	1.418		
	Collaboration	3.30	1.295		
	Critical Thinking	3.74	1.077		
	Digital literacy	4.38	.713		
	Creativity	3.42	1.247		
	Content Mastery	4.09	.925		

Appendix H

Revised Items for Pilot Testing

Collaboration	**Communication**	**Content Mastery**	**Creativity**	**Critical Thinking**	**Digital Literacy**
Working through conflict. (17)	Using peer feedback to make improvements. (4)	Connecting schoolwork to the real world. (10)	Solving digital world problems (blocked websites, password protected domains, etc.) (1)	Thinking deeply about information encountered online. (16)	Assessing online information for reliability. (2)
Working with others on projects and assignments. (23)	Discussing research with teachers and other students. (6)	Using websites to help with homework. (18)	Creating engaging multimedia presentations. (5)	Expanding perspectives through online interactions. (19)	Using a digital device for real-world tasks. (3)
Organizing group work. (26)	Participating in online discussion boards. (7)	Learning through online sources. (24)	Developing virtual models of concepts. (12)	Considering others' opinions and perspectives. (20)	Independently dealing with questionable information. (11)
	Planning extracurricular activities through online platforms. (8)	Finding websites that make schoolwork meaningful. (30)	Creating new ways to do things online (programming, coding, etc.). (14)	Maintaining focus during class. (22)	Recognizing bias in media. (15)
	Discussing approaches to problem solving. (13)	Using search results to help with learning. (34)	Setting my own parameters. (21)	Asking relevant questions in class. (29)	Choosing online resources for research. (28)
	Emailing teachers. (25)				
	Giving peers feedback. (32)				
	Eliciting others' opinions. (33)				

Eliminated: Items 9, 27, 31

Appendix I

Image Permissions/Proof of Open Access

Figure No.	**Caption**	**Source**	**Permission**
1	First generation activity system	https://commons.wikimedia.org/wiki/File:First_Generation_CHAT.jpg	Not needed
2	The socially distributed activity system	https://commons.wikimedia.org/wiki/File:Second_Generation_CHAT.jpg	Not needed
3	Shapes designed and created in physics class using a 3D printer	Photo taken by researcher	Not needed
4	The product of a physics-related project hanging from the classroom ceiling	Photo taken by researcher	Not needed
5	Frequencies of students' perceptions of effective content mastery resources	Graph created by researcher	Not needed
6	Student illustration of the learning process in a one-to-one initiative high school	Illustration contributed as data during focus group interviews	Obtained through IRB consent/assent process
7	Teachers' described process of digital literacy development	Flow chart created by researcher	Not needed
8	Subject matter experts' length of experience in schools with technological elements	Graph created by researcher	Not needed
9	Subject matter experts' length of experience in 21st century skills programs	Graph created by researcher	Not needed