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The Intersection of Collaboration, Critical Thinking and Technology: Implications for Adult ESL Learners using an Inquiry Approach

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THE INTERSECTION OF COLLABORATION, CRITICAL THINKING AND TECHNOLOGY: IMPLICATIONS FOR ADULT ESL LEARNERS USING AN INQUIRY APPROACH

by

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DEDICATION

To our newest Americans, may you find the community, support, and education you need to build a new life in the United States. Thank you to my family and friends for challenging me to reach farther. A special thank you to my fellow observer, Laura Dale Bischof, who was stellar in her reliability and accuracy. To my good friend and colleague, Jessica Jones, who allowed me to observe her excellent lessons; I am so appreciative and fortunate. And finally, thank you to my Capstone Committee for your guidance through this labor of love. It has been a fulfilling journey.

"21st Century Education won't be defined by any new technology. It won't be just defined by 1:1 technology programs or tech-intensive projects. 21st Century Education will, however, be defined by a fundamental shift in what we are teaching - a shift towards learner-centered education and creating creative thinkers".

- Karl Fisch

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CHAPTER ONE: INTRODUCTION

One of the guiding principles of education is the development of a person's knowledge and understanding about the world in which one lives and interacts. It is the task of educators to give learners the tools necessary to be creators, decision makers, engaged members of society. Like never before, our society is moving and adapting to a changing environment at an increasingly rapid pace. Knowledge and skills that were in demand only thirty years ago are no longer sufficient in today's post-industrial knowledge-based society. Our new Americans, who are arriving from very different economic and social structures, are finding themselves challenged by a very different socio-economic paradigm. Among the major barriers to economic self-sufficiency for adults in this country are English proficiency and education. Education, no longer restricted to the traditional K-12 school system and higher education, is now considered a life-long process of acquiring new skills and knowledge required by the workplace.

Adult Basic Education (ABE) is growing into a new and expanded role within the field of education, one that is responsible for preparing adults to transition successfully to the 21st Century workplace, career training, higher-education and community involvement. According to the Partnership for 21st Century Learning (P21), critical thinking, communication, collaboration, and creativity are the learning and innovative skills demanded by our increasingly complex, and interrelated global society (Partnership for 21st Century Learning, n.d.). Also under the umbrella of education, digital literacy is now recognized as one of the critical literacies needed to fully participate in today's society (Donovan, 2007; Partnership for 21st Century Learning, n.d.; Hawisher & Selfe, 2004). In fact, the National Education Association (NEA) states in *An Educators Guide to the "Four Cs"* that problem solving in the 21st Century requires that we can work effectively and creatively with computers, with diverse people, with uncertain situations, and with vast amounts of information (National Education Association, n.d.). Adult educators are challenged with the task of adequately preparing a diverse adult student population to be critical thinkers, able to collaborate and communicate effectively in a technology driven society.

As an adult educator, I am acutely aware of the urgency to help my learners develop the skills they need to have choices in their work-life and community. From the perspective of social justice and equity, it is our duty as professionals to prepare learners adequately for 21st Century life in America. Much of our refugee population finds themselves living in poverty in their new country, limited by low-paying jobs and a language barrier. Many of our learners come from education systems that did not emphasize the innovative skills in demand in the United States such as collaboration, critical thinking and digital literacy skills.

Although there is recognition within the field of Adult Basic Education of the need to teach 21st Century skills, successful classroom models are necessary to help the field grow into the standards that are being developed. I want to find out how ABE instructors are preparing learners to transition successfully beyond ABE to college and the workplace.

In this thesis, I will explore how the inquiry approach defined below uses technology to help ESL adult learners develop and practice critical thinking skills and collaboration skills. I will examine how collaboration facilitates critical thinking as well as how critical thinking, collaboration and technology address transition skills for 21st Century life (Harvey & Daniels, 2009; Kuhlthau, Maniotes & Caspari, 2007; ATLAS, 2013). Specifically, I will examine how advanced ESL adult learners collaborate with each other as they learn a new technology skill and how inquiry-based learning may be a natural environment for learning new digital skills as well as practicing critical thinking skills.

For the purpose of this thesis, I will use the term inquiry-based learning to describe an approach that encourages students to use their current knowledge to make meaning and solve problems in new contexts through questioning, experimentation, evaluation and reflection (Audet & Jordan, 2005; Barell, 2007; Harvey & Daniels, 2009; Kuhlthau, Maniotes & Caspari, 2007). Inquiry-based learning is associated with constructivist learning theories that have inspired many similar instructional approaches such as discovery learning, problem-based learning, and project-based learning. Collaboration will be considered as the ability to work effectively and respectfully with diverse teams; be flexible and willing to compromise in order to accomplish a common goal; value individual contributions of team members and share the responsibility for collaborative work (Partnership for 21st Century Learning, n.d.). In this current project, inquiry and collaboration with technology provide the background for investigating critical thinking skills.

Critical thinking is the disciplined, yet open-minded thinking that enables a person to compare evidence, evaluate competing claims, and make sensible decisions that go beyond factual recall (ATLAS, 2013). Critical thinking skills include the ability to reason effectively, solve problems, make judgments and decisions, and use systems thinking (ATLAS, 2013; National Education Association, n.d.). Considered one of the professional soft skills of the Transitions Integration Framework (TIF) (ATLAS, 2013), the category of critical thinking has been sub-divided into four skills:

- organize, analyze and illustrate the relationship between ideas, components and items
- solve problems
- use information to draw conclusions and make decisions
- recognize bias, assumptions, and multiple perspectives

Each of these four skills are further subdivided into sixteen sub skills that serve as a useful checklist for practitioners (see Appendix A). Other assessment tools that articulate and provide a rubric of emerging and competent critical thinking skills such as the Critical Thinking Value Rubric (Association of American Colleges and Universities, n.d.) come from the Foundation for Critical Thinking (Paul & Nosich, 1993) or higher education institutions.

In 1997, a study was conducted on 38 public and 28 private Universities to determine faculty emphasis on critical thinking in instruction (Paul, Elder & Bartell). Findings showed that while the majority of faculty (89%) claimed critical thinking was a primary objective in their course, few (19%) could sufficiently define critical thinking and 77% had limited or no conception of how to integrate critical thinking with content.

Based on these outcomes, recommendations for policy change were made starting at the K-12 level that included professional development on critical thinking skill-building and instructional strategies (CEO Forum on Education and Technology, 2001; Partnership for 21st Century Learning, n.d.). Since then, studies on development of critical thinking skills continue to emerge® across disciplines as practitioners and stakeholders from K-12, training and vocational programs, and universities realize the importance of preparing learners to be critical independent thinkers. Listed as one of the 4 Cs by the Partnership for 21st Century Learning (n.d.), critical thinking has also become a buzzword in the field of education. But what does this look like in different classroom contexts? The most traditional and established discipline to explicitly practice critical thinking is in the field of science and using the scientific method, a discipline that has long used the inquiry-based approaches as student work to uncover the rules and patterns of the natural world. However, critical thinking as an intentional strategy is still emerging as part of instruction in Adult Basic Education. It is my hope that this thesis will offer one model for critical thinking development as part of integrated technology instruction. Connecting inquiry-based learning and the development of technology skills in adult education only makes sense, given the demands of today's workplaces, postsecondary options, and communities.

We engage in different types of thinking each day depending on the task and situation. Perhaps one needs to memorize another password, solve a computer problem, read and evaluate a research paper, or decide on what to make for dinner with the ingredients in one's fridge. While all these different kinds of thinking are important and necessary, they are not all in the category of critical thinking. Critical thinking is the ability to compare and contrast, problem-solve, reflect and evaluate, and connect ideas (ATLAS, 2013; Partnership for 21st Century Learning, n.d.). It involves complex thinking in that there is no single correct answer or idea. Bloom developed a taxonomy of cognitively demanding skills to inform educators when designing learning and assessments (Bloom, Krathwohl & Masia, 1956). This taxonomy of knowledge and intellectual skill development was seen as a hierarchical progression of knowledge, comprehension, application, analysis, synthesis, and evaluation.

Since this taxonomy was developed, other schemas have been proposed to assess cognitive demand. Among these is Webb's Depth of Knowledge Levels (DOK) and includes four levels of mental processing complexity. This model is not a taxonomy per se in that all levels of thinking are considered important and movement between levels is not contingent on mastery of the previous level (Webb, 2002). Yet, there is an increasing level of cognitive rigor in activities from levels one through four. The first level of this framework is recall and reproduction where answers tend to be clear. The next level is skills and concepts and is the level that explains the how or what. The third level is strategic thinking/reasoning and answers the why with evidence and argument and is where critical thinking presides. The final level is extended thinking where creative thinking occurs over a period of time. Webb's DOK has been used to inform the K-12 Common Core Standards and the new GED® test is asking questions specific to levels 2 and 3 of the framework (GED® Testing Service, 2015). Critical thinking is a cognitively complex endeavor that we want to develop in our learners, and therefore we need ways to measure development of these skills. Both Bloom's taxonomy and Webb's DOK are helpful references when designing cognitively rich lessons.

Researcher and Participants

When I first began teaching in adult basic education, I ran a computer lab for an adult learning center and assisted ESL classes in using Microsoft and education software. It was a typical looking desktop computer lab with individual students working independently until they got stuck or accidently got lost in cyber space. There were 16 Mac desktop computers and ESL classes would take turns using the computer lab to practice English at their teacher's webpage. Teacher webpages included links to English practice websites as well as word documents that students would open and edit. *Computer time* was a frantic period of running from one raised hand to another putting out fires and solving basic digital problems for students.

As computers became more integrated into lessons and laptops replaced labs, the constant trouble-shooting still remained a major characteristic of *computer time*. In my ESL class, there also persisted the question of what technology skills to teach ESL adults with various levels of literacy and technology exposure. As a daily user of technology, I spent a lot of time problem-solving both hardware and software issues and wondered how I could better prepare students for the complex process involved in using technology. I realized that learning to use a computer was not a rigid step-by-step process with assured successful outcomes because a computer's interface is a dynamic mosaic of text, images, links and tools that are constantly changing. Many of the computer curriculum resources I found were step-by-step guides and procedures while digital learning in practice was much more concept based. Concept based knowledge is an understanding of how the part relates to the whole. For example, learners with a conceptual understanding of something are not dependent on sets of learned procedures and they can apply their knowledge in new and novel situations both in and outside of the classroom. Conceptual knowledge is necessary for successful problem-solving and creative thinking in a domain. For example, consider how to save a file; it depends on how you want to use and access the file. One may just save it to the computer, or save it to the cloud. It could be saved on a USB drive or attached as an email and sent to oneself. There is not one correct procedure. Having a conceptual knowledge of files and storage options is necessary so that learners can choose the best location to save a file for their specific purposes. Furthermore, step-by-step procedures developed by publishers, curriculum writers and teachers cannot keep up with the rapid changes that occur in technology. As I considered how to best develop digital literacy in my learners, I needed to address two issues:

- how to teach the most critical digital literacy skills within the time constraints of ABE.
- how to help students become independent technology users.

While I considered digital literacy in my classroom and program, the state and country were also having a conversation around building a better-prepared workforce that would meet the needs of the 21st Century. The Partnership for 21st Century Learning (P21), a collaboration between education leaders, the business community and policymakers, put the issue of 21st century skills for all students front and center in this conversation (Partnership for 21st Century Learning, n.d). P21 recognizes that learning is a lifelong process and identifies a diverse set of skills that all learners need to succeed in a rapidly changing world. The framework put forth by P21 has segments that illustrate the knowledge, skills and expertise necessary to thrive in today's global economy. In addition to key subjects, there are also the components of life and career skills, learning and innovation skills, and information, media and technology skills. Each of these elements is considered interconnected and central to teaching and learning. Students must be able to apply the 4 Cs of learning and innovation skills, critical thinking, communication, collaboration, and creative thinking while utilizing multiple media and technologies to engage in 21 Century themes such as civic and environmental literacy. In other words, technology use is dependent upon the ability of users to access and critically evaluate vast amounts of information across subject matter and environments. Teaching and learning must include the integration of these diverse sets of skills across all content areas.

In Minnesota ABE, three main skill areas are defined as necessary to help adult learners transition successfully to the workplace and postsecondary education. These three skill areas are driving ABE instructional practices and professional development and are defined as basic skills, professional or soft skills, and digital literacy skills (ATLAS, 2015). These skills are integrated with the content of the ABE class depending on the objectives of the context and program. Content may be life skills for new immigrants and refugees, math, science, social studies and Reading Language Arts for GED® programs, or an occupational focus for a vocational bridge class. Minnesota ABE has adopted three documents to guide implementation for each of the three skill categories. The College and Career Readiness Standards (CCRS) derived from Common Core are a set of standards that address basic skills of English language arts/literacy, math, and foundational reading skills. Transitions Integration Framework (TIF) (ATLAS, 2013) includes important transitional soft skills such as self-management and critical thinking that are key to adult success in the community, workplace and higher education (ATLAS, 2013). And finally, digital literacy skills are addressed with the Northstar Digital Literacy Standards (NDLS) that focus on basic computer and online skills and include modules such as World Wide Web, PowerPoint, and Social Media (Northstar Digital Literacy Project, 2014).

These documents prompted me to consider how educators could better integrate technology seamlessly into existing curriculum while addressing College and Career Readiness Standards and the soft skills of the Transitions Integration Framework. While the NDLS provided a set of digital standards, I found that the set of standards were too narrow for the more integrated technology projects, for example, creating an iMovie to share information. The iMovie group project that my class participated in did not address any of the NSDL standards and yet demonstrated integration of technology skills set forth by the CCRS and TIF such as Speaking and Listening Standard 5; make strategic use of and integrate multimedia and visual displays to express information and enhance understanding of presentations (CCRS, 2013). Dissatisfied with the current set of digital standards set forth by NSDL, I will look at one approach to integration of 21st Century digital skills in an adult education ESL class that goes far beyond NSDL but meets the sophisticated skills demanded by CCRS and the TIF.

In considering how to best address digital literacy in the ESL adult classroom, the first issue was how to teach the most critical digital literacy skills within the time constraints of ABE. To address my second issue of how to help learners become more independent, critical users of technology, and on the suggestion of a colleague, I tried the approach of collaboration to help learners become more independent problem-solvers. Collaboration provided the support and confidence for learners to try problem-solving themselves. Working with partners enabled learners to pool their knowledge as they constructed meaning and learned new concepts through language. Students became the problem-solvers as they worked together in pairs or groups on a single computer or device. Some students even got up to check out other group's strategies, whether it was with Microsoft word, email or iMovie. I began to think about how technology, collaboration and problem solving all came together naturally during this process of learning and yet there was still opportunity for improvement. Not all pairs managed to trouble-shoot effectively. Some pairs had one partner who controlled the computer and the other who watched. I wanted to know how I could facilitate collaboration skills in student pairs and how to guide pairs through more complicated technological tasks that required critical thinking.

In this study, I watched ESL adult learners become more independent, critical users of technology in one teacher's classroom. This particular teacher uses collaboration through inquiry to learn and apply new digital skills. I observed and recorded evidence of problem-solving and higher order cognitive skills in ESL adult learners when presented with complex tasks requiring use of digital tools. Learners are challenged with the task of learning how to use a new feature of a program with little direction from the teacher. Learners worked together in groups as they applied existing knowledge to learn a new feature. The teacher introduced new concepts and symbols that were integral to the computer task that students needed to perform. The teacher's role during this inquiry process was to facilitate, probe, and clarify objectives. The inquiry method shifts the focus away from the teacher as the expert and instead relies on learners to pool their knowledge and critical-thinking skills to achieve an outcome. It is such peer collaboration occurring in the environment of inquiry-based learning that is a central focus of this study.

Guiding questions

The purpose of this study is to determine how the collaborative use of technology can help adult ESL learners develop and practice critical thinking skills and how the cooperative learning process facilitates the learning of new technology skills. In this study, I will consider the following questions and attempt to give a tentative answer to each of the questions under consideration. *In learning digital literacy and technology skills via an inquiry approach, what types of critical thinking skills are utilized by learners? What level of cognitive complexity is involved in learning digital skills through inquiry-based learning?*

Summary

The ability to communicate, collaborate, think critically and use diverse types of technology is of utmost importance in a knowledge-based economy. Additionally, strong English language skills are necessary to participate in career trainings, higher education and the workplace. Individuals who lack these skills find themselves struggling to move beyond low paying jobs. These factors have great implications for our immigrant and refugee population as well as our under-educated native-born population. ABE educators are in an opportune position to incorporate many of these 21st Century skills into their curriculum. By investigating one classroom of adult ESL learners, I hope to provide a model that addresses the specific needs of adult ESL learners in preparing for college, careers and more meaningful community participation.

Chapter Overview

In Chapter One, I have introduced the purpose and significance of this study and addressed the need for this particular study. I provided the context and participant roles for the study and included the assumptions and biases of the researcher. In Chapter Two, I examine the current field of research and provide a review of literature on the topics of inquiry-based learning, collaboration and critical thinking as well as technology and digital literacy as it relates to adult ESL learners. I connect this research to the particular classroom of adult ESL learners and consider the current inquiry model as it relates to these learners. Chapter Three provides a description of the research design and methodology employed in this study with step by step procedures. In Chapter Four, I discuss the study results and data analysis as they relate to the research questions. Finally in Chapter Five, I reflect on the relevance of the data for the field of ABE. I also discuss the limitations of the present study and identify additional areas for research.

CHAPTER TWO: LITERATURE REVIEW

The purpose of this study is to determine how the collaborative use of technology through inquiry-based learning can help ESL adult learners develop and practice critical thinking skills. The core research questions are as follows: *In learning digital literacy and technology skills via an inquiry approach, what types of critical thinking skills are utilized by learners? What level of cognitive complexity is involved in learning digital skills through inquiry-based learning?*

In this chapter, I look at Adult Basic Education and programmatic goals for English language learners. Next, I examine technology in adult education programs and review current research on technology integration as specifically related to content standards for ABE. I consider research on inquiry-based learning and how the role of collaboration fits with this instructional approach. I review the research on collaboration and learning in light of constructivist theories of learning. Additionally, I discuss the current field of research surrounding collaborative learning particularly with adult learners. Lastly, I consider critical thinking theories and instructional recommendations and I provide relevant research on critical thinking and its connection to inquiry-based learning and collaboration. The information graphic (Figure 1 below) illustrates the relationship between inquiry-based learning and critical thinking, collaboration, and technology integration within an environment of ABE standards. Inquiry-based learning provides the stage for integrating many 21st Century skills including critical thinking, collaboration and technology. The inquiry-based approach provides a rich context for student learning through real-world questions and problems and allows for the seamless integration of content standards and soft skills, technology, critical thinking as well as collaboration and communication practice through team work.

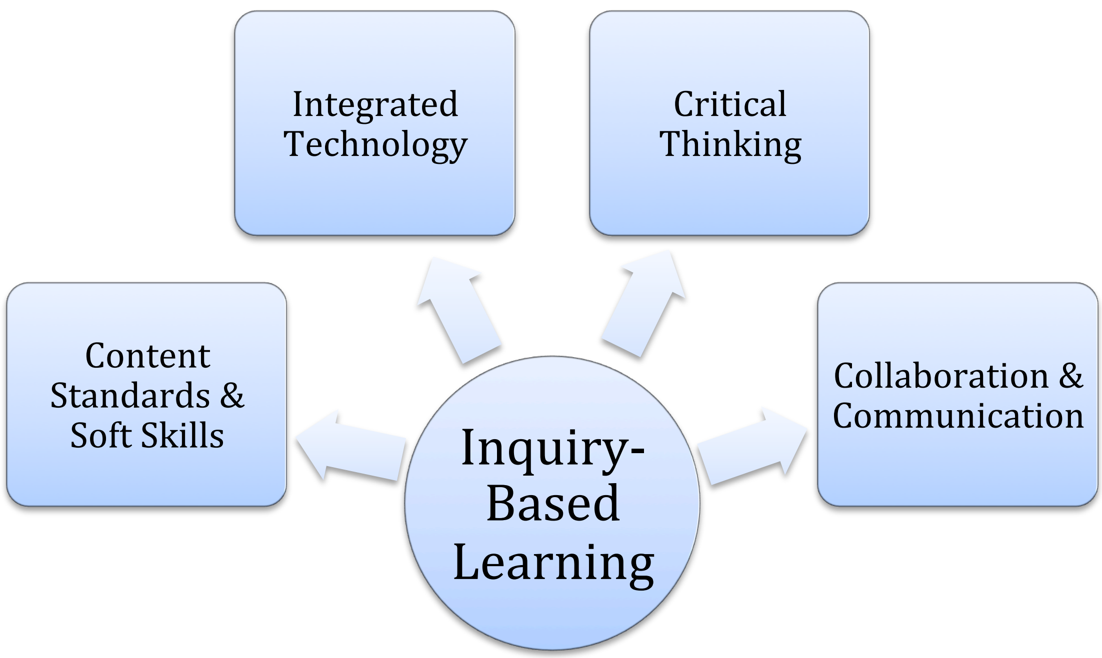

Figure 1: Inquiry-Based Learning and 21st Century Skills

ABE Standards and the Adult ESL Learner

Adult Basic Education is in the process of repositioning itself as an integral part of workforce, training and higher-education preparation (Minnesota Department of Education, 2014; National Council for Adult Learning, 2015). According to the U.S.

Census Bureau (2013), 61,748,740 people five and older speak a language other than English at home and of this group, 70.6% were between the ages of 18 and 64 years. 29% of people over the age of 25 who speak a language other than English have never completed high school compared with 9.4% of people who only speak English at home. For speakers of home languages other than English five and older, 21.2% live below poverty level compared with 13.7% who speak only English at home. These data provide us with an understanding and context for the role adult education must play in moving non-native English speakers out of poverty. Literacy and English proficiency are barriers that can be dismantled with strong adult education programs and government support. Workforce instruction and preparation is receiving increasing attention from the federal government as evidenced by the Workforce Innovation and Opportunity Act (WIOA)(U.S. Department of Labor, 2014), which helps job seekers access education, training, employment and support services and matches employers with skilled workers. Within Adult Basic Education, models of transitions that move learners to the workplace and college may take various forms including Adult Diploma, GED®, English as a Second Language (ESL or EL), Family Literacy, Basic Skills Enhancement, Workplace Literacy, and U.S. Citizenship/Civics (Minnesota Department of Education, 2015). ABE classes may take place in workplace settings, public schools, non-profit and community-based organizations, technical colleges and state and local correctional institutions.

Standards based education has been evolving in K-12 contexts resulting most recently in the development of the Common Core State Standards (CCSS), which has been adopted by 46 states including Minnesota in 2010. The goal of standards-based education is to provide educators with benchmarks of skills and knowledge deemed essential for students entering post-secondary training, work and citizenship (Pimentel, 2013). Adult Basic Education in Minnesota now considers three essential components in preparing learners for the workforce, higher education, training and civic engagement: College and Career Readiness Standards (CCRS), which addresses academic skills; Northstar Digital Literacy Standards (NDLS), which provides a guideline for technology skills; and ACES, providing a transitions framework (TIF) for soft skills (ATLAS, 2013). These three components of ABE are not considered separate silos of learning but rather overlapping and complementary skills preparing learners for full participation in work, community, and academic life. While the TIF and the CCRS call for integrated use of technology in the classroom, they are not a digital guide per se. In contrast, the NDLS are so discrete in skills that they will have difficulty keeping pace with the diverse digital and media formats that are constantly evolving. CCRS anchors go far beyond the discrete skills laid out in the NDLS but do not provide enough digital literacy guidance to address the complexity of digital skills demanded by these standards. These new College and Career Readiness Standards do indicate that in response to our changing social environment, educators must help learners move from learning how to use tools of technology to using tools to create, solve problems, think critically.

The Northstar Digital Literacy Assessment project was launched in 2010 in Minnesota to develop a set of standards that addressed the most critical digital literacy skills needed to succeed in the 21^{st} Century workplace and learning environment (Northstar Digital Literacy Project, 2014). Participation in the process was broad and included the Minnesota Department of Education, the Minnesota Department of Employment and Economic Development (DEED), non-profit community-based organizations, libraries, workforce programs and ABE professionals. The Northstar Digital Literacy Standards were developed based on the most foundational skills necessary for computer and Internet use. A set of digital assessments also resulted from this process that would measure adult digital literacy skills and award a certificate for module mastery. Currently, there are nine modules covering basic computer skills, World Wide Web, Windows, Mac OS X, Email, Word, Excel, PowerPoint and Social Media. Each module is broken down into discrete skills that are used as standards and as assessment components. For example, Windows includes skills such as identify the toolbars and menus, use "Search" to locate a file of document, and open files using appropriate programs. Learners take assessments based on these nine key areas of computer literacy. While there are a limited amount of questions where learners must demonstrate a task, for example, compose a new email, the assessments are strictly click and answer. This format works well as an introduction to various skills for a broad audience. However, this type of assessment is as cognitively complex as level 1 depth of knowledge (DOK 1), recall and reproduction, according to Webb's Depth of Knowledge Guide (2009). The assessment follows a step-by-step procedure for using a computer and applications with only one correct answer possible. A problem may arise with such a method whereby a learner may pass all the Northstar Digital Literacy assessments but may still be unable to independently apply much of what she has learned, such as create and use an Excel document. The definition of digital literacy according to the American Library Association "is the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills," (ALA Digital Literacy Taskforce, 2011). While Northstar Digital

Literacy Standards provided a starting point for incorporating digital literacy skills, digital literacy requires the integration technology into lessons where learners would be required to use more complex cognitive processes to apply skills and knowledge (DOK 2) or solve real world problems (DOK 3). Digital skills need to be taught in a way that promotes critical thinking and independence.

In 2013, College and Career Readiness Standards (CCRS) for Adult Education was released as a rigorous set of academic standards for adult education programs which include standards in content areas (Math and English Language Arts) that prepare adults for training programs and higher education (Pimentel, 2013). Adult education stakeholders such as the National Reporting System (NRS), Workforce Innovation and Opportunity Act (WIOA), and federally approved ABE assessments such as TABE® and CASAS, and the high school equivalency exam, GED®, are currently or are in the process of being aligned to the CCRS[1] (CASAS, 2015; GED® Testing Service, 2015; TABE, 2014). Although content areas include reading, writing, speaking and listening, language, and math, technology is embedded into standards. For example, CCRS writing anchor standard 6 asks learners to: "Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others" (p. 27). CCRS reading standard 7 includes "Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words" (p. 19). Speaking and listening standard 2 and 5 as well as Standards of math practice include use of digital

[1] TABE® refers to the Tests of Adult Basic Education and includes the skills of reading, language, language mechanics, spelling and math. CASAS is the Comprehensive Adult Student Assessment System, a standardized set of tests used predominantly with adult ESL learners to measure basic skills proficiency. GED® refers to the General Educational Development tests, which measure skills and knowledge of high school level courses.

media. Digital standards are not separate but rather integrated into various CCR anchor standards and level-specific standards.

The ABE professional development initiative ACES (Academic and Career Employability Skills) created the Transitions Integration Framework (TIF) as a guide for the integration of transition skills in ABE curriculum (ATLAS, 2013). Professional development in the form of workshops, webinars, professional learning communities, and regional trainings are offered around the state of Minnesota to help teachers integrated these essential skills. The TIF provides teachers with transition categories that address potential skills gaps in current adult curriculum. This framework identifies academic, career, and employability skills essential for adult learners to move beyond ABE to postsecondary education, career training, the workplace and community involvement (ATLAS, 2013). The TIF is the result of state transition leaders identifying categories of critical transition skills as informed by stakeholders in ABE, postsecondary education, employers, and community-based organizations, and relevant research. The resulting document includes six categories[2]: effective communication, learning strategies, critical thinking, self-management, developing a future pathway, and navigating systems. Each category is divided into skills and sub-skills along with sample activities for a range of contexts, complexity levels and technology instruction options. Similar to CCRS, technology options in the TIF are integrated into each category rather than being considered as a separate category, very different from the traditional practice of teaching technology skills as a separate component of class-time and often referred to as *computer time.*

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[2] The TIF originally contained eight categories but has recently been revised with Numeracy and Academic Language categories being removed in light of CCRS.

ABE Content Standards provide a backdrop to the current study, which shows how one model begins to address multiple standards while also teaching technology skills to adult ESL learners. While there is recognition in ABE of the importance of teaching academic and transition skills, very little research exists to date on using integrated approach to teaching these skills, and specifically digital literacy and technology skills (Lesgold & Welch-Ross, 2012a). Furthermore, research involved in teaching technology to adult ESL learners focused on direct procedural instruction with little to no attention given to cognitive complexity of digital tasks. In this study, I will investigate how the pedagogical approach of inquiry-based learning creates a collaborative learning environment ripe for critical thinking and technology integration.

Integrated Technology

Concern over adequate student preparation for a demanding global economy has resulted in 21st Century Readiness Act: HR347 (113th Congress) and S1175 (112th Congress) introduced in 2011, which fuses critical thinking and problem solving, communication, collaboration and creativity (4 Cs) with core academic subjects and provides monetary support to local and state initiatives around this fusion. As a result, there is much research and support for implementing technology and the 4 Cs in K-12 and higher education (Pahomov, 2014; Pitler, Hubbell, Kuhn & Malenoski, 2007; Starkey, 2012; Partnership for 21st Century learning, n.d.). However, there is less available research on the development of 21st Century skills among adult basic education (ABE) students and specifically adult English language learners. In fact, the field of adult literacy instruction has largely been overlooked by research. This is partly due to the funding structures of ABE, which receives significantly less than the K-12 education system and higher education. Minnesota ABE is currently in the process of integrating the Transitions Integration Framework (2013) and CCRS (2013) into instruction at all levels of ABE. The Transitions Integration Framework describes eight categories of transition skills that are essential for transition to postsecondary, the workplace, and community participation, one of which is critical thinking. Technology is considered an essential part of instructional practice rather than being considered a separate, discrete skill to be mastered. Similarly, the College and Career Readiness Standards has integrated technology across content areas, supporting the practice of embedding digital skills as needed to meet specific standards. It has been advised that incorporation of technology into instruction should move beyond a drill and skill approach to a conceptual understanding of digital tools (Hayes in Belzer, 2007; Lesgold & Welsh-Ross, 2012b; Meskill & Mossop, 1997). In order to arrive at this outcome, teachers need opportunities to receive training in best practices for technology integration. Technology integration in instruction may cause a pedagogical shift from teacher-centered to learner-centered as students take a more active role in their learning (Mize & Gibbons, 2000; Rice, Wilson, & Bagley, 2001).

Technology is a means of connecting and interacting with the world, a tool that takes many forms. At present, the cell phone is the most accessible form world-wide. By the end of this decade, five billion people globally will be connected to the web through smart phones, tablets and other devices (Pitler, Hubbell & Kuhn, 2013). In a 2012 national report (Lesgold &Welch-Ross, 2012a) on improving adult literacy instruction, it states the tools of literacy have moved beyond pen and paper to include digital forms of expression through multimodal communications and information media.

While there have been some studies on technology integration in adult ESL settings, they have been limited to learning to use technology tools rather than using technology tools to engage in meaningful real-world exercises (Sparks, 2014; Northstar Digital Literacy Project, 2014). However, there are many resources for technology integration at the K-12 level that focus on the higher cognitive processes of Bloom's Taxonomy (Pitler, Hubbell & Kuhn, 2013). A report by the CEO forum (the CEO Forum on Education and Technology, 2001), states that, "technology can have the greatest impact when integrated into the curriculum to achieve clear, measurable educational objectives" (p. 4). Although skill and drill has its place with factual recall, technology should also be used for analysis, synthesis, and evaluation of information. Ted Hasselbring, co-director of the Learning Technology Center at Vanderbilt University's Peabody College in Nashville, Tennessee, identifies three main steps to mastering basic digital skills for learners: developing the skill initially, becoming fluent at it, and being able to apply it across different activities and content areas (as cited in Heide & Henderson, 2001). The non-linear nature of hypermedia technology requires users to think in new patterns that are very different from printed sources. The current study focuses on how technology can be used as a tool in a guided inquiry environment where peer collaboration encourages communication of ideas, which may in turn foster higher order thinking skills. Student inquiry involves students collaborating with each other to solve a problem by sharing ideas for solutions and testing and evaluating results in ways that elevate their learning. Technology use and collaboration both require active reflection and problem-solving, which may be enhanced through social engagement with peers (Pitler et al, 2013).

This study moves beyond "how to use the tool" towards "what real-world problem can we solve with this tool?" I examine how technology can be used as a tool to practice transition skills, and specifically, critical thinking skills in an inquiry-based environment. This study is designed to assess the hypothesis that inquiry-based instruction allows for the integration of technology and critical thinking skills through the process of collaboration with ESL adults. Furthermore, I investigate whether the integration of technology and critical thinking enhance depth of learning due to the cognitive complexity of the tasks involved in an inquiry-based approach. I look for evidence of critical thinking skills that are verbalized in student collaboration while they are creating an Excel spreadsheet for the first time. This study adds to a newly emerging field of inquiry-based instruction in adult ESL, a much more established research area with K-12 programs. In order for Adult Basic Education to develop best practices for learner instruction that address multiple sets of standards, more research is necessary in order to inform the field of ABE instruction. To date, very little research exists on using an inquiry-based approach to teaching digital literacy and technology skills. Specifically, there is less available research on the development of 21st Century skills among adult basic education (ABE) students and specifically adult English language learners. This study investigates how technology instruction may be enhanced through an inquiry-based approach as well as the critical thinking skills that may be practiced in this environment.

Inquiry-Based Learning

Inquiry-based learning is rooted in the constructivist perspective of learning by searching for meaning and constructing knowledge through personal connections to others and the world. Constructivism arises from the sociocultural theories hold that learning is augmented through purposeful, structured social interaction with others (Bruner, Piaget & Vygotsky as cited in Audet & Jordan, 2005). Social psychologists Johnson & Johnson (1987, 1989) remind us that humans are by our very nature social with a cooperative imperative to survive. It is from this perspective of meaning making that educational approaches such as inquiry-based learning are grounded. Inquiry is the search for understanding, which in the educational context involves students working collaboratively to learn content and reasoning skills through investigations, research, quest, and exploration (Kuhlthau, Maniotes & Caspari, 2007).

Inquiry-learning is part of a larger family of classroom approaches that includes problem-based learning, situated learning, experiential learning and project-based learning (Hmelo-Silver, Duncan & Chinn, 2007). All of these approaches place the student at the center of the learning process. Rather than being teacher-directed, the students determine how to tackle problems and questions that are based on real world situations and just-in-time teaching is used to give students enough skills to be able to process at a deeper level. The steps in the inquiry process follow a similar pattern to the scientific method of explore and ask questions, investigate, analyze and synthesize information, and share learning with the larger community. These stages are not rigidly defined but regarded as a flexible and adaptable model that can be tailored to different types of investigations such as mini-inquiries or long-term inquiry projects (Harvey & Daniels, 2009). In an English as a second language classroom, inquiry-based instruction has been shown to be successful when learners are provided with a shared common experience, hands-on activities are built in, prior knowledge is activated, peer collaboration is modeled and practiced, and focused language teaching experiences are meaningfully incorporated into the lesson (Audet & Jordan, 2005).

There has been some criticism of inquiry-based learning that considers it a minimally guided instructional practice because it fails to provide direct instructional guidance resulting in ineffective learning. Kirschner, Sweller, and Clark (2006) considered programs that required students to solve authentic problems where learners must construct their own solutions or learn by doing did not value instructional guidance. According to these researchers, the constructivist perspective concerning learning strategies embedded in instruction considered such strategies as interfering with the natural process of constructing knowledge. These researchers claim that constructivist instruction does not allow for deep processing because working memory is given over to problem-based searching without instructional support leaving no room for long-term learning. Unsurprisingly, studies are cited where students who received minimal feedback often became lost or frustrated. As a counter argument, Hmelo-Silver, Duncan and Chinn (2007) refute the claim that inquiry and problem-based learning are unguided approaches. To the contrary, these researchers point out the flaw in lumping all constructivist approaches together in the category of minimally guided instruction. They provide evidence of problem-based learning and inquiry learning including direct instruction as one of the many scaffolding strategies used to guide instruction and reduce cognitive load. Interestingly, Hmelo-Silver, Duncan and Chinn (2007) present research that suggest inquiry-based learning environments create better engagement and goal orientation mastery among disadvantaged students over traditional instruction and that inquiry-based instruction was successful in reducing the achievement gap experienced by

African American boys. The Kirschner, Sweller, and Clark (2006) article also contradicts professional development resources on inquiry and problem-based learning, which are filled with variations in inquiry methods and the scaffolding of critical skills development (Audet and Jordan, 2005; Kuhlthau, Maniotes and Caspari, 2007; Barell, 2007).

As a practitioner, I find it naïve to generalize instructional theories as pure methods that a teacher will adhere to as laid out by the theorists. Teachers use a variety of strategies and approaches depending on objectives, learner needs, time of year, instructional goals, amount of learner background experience and the nature of the learning activity. Inquiry-based learning can be viewed on a continuum rather than an all or nothing approach as alluded to by Kirschner, Sweller, and Clark (2006). It may be short-term or long term, teacher-directed inquiry, teacher-student shared inquiry, or student-directed inquiry (Barell, 2007). In Pahomov's *Authentic Learning in the Digital Age* (2014), she states that inquiry is not a free for all. Instead guidance is used to help learners apply thinking strategies to other areas beyond one specific task. Good teaching is a balance of direct explicit instruction as well as indirect student-led inquiry. Research on adult literacy instruction supports direct strategy instruction such as guided practice and think-alouds with adult students including ESL and those with learning disabilities (Kruidenier, MacArthur & Wrigley (2010). Inquiry-based learning can only be successful after basic skills and concepts of a discipline have been addressed. Inquiry-based learning moves beyond learning how to do a specific task and can be used to expend and deepen student knowledge, a crucial component of student learning. The skills related to inquiry take practice and learners should have frequent opportunities to use skills such as collaboration and questioning. In sum, there is a place for direct explicit instruction when teaching conceptual understanding and procedural fluency and indirect inquiry-based instruction at the application and extension level. Ideally, students will have the opportunity to move through all these levels of learning.

There is a general agreement among leaders in the field that 21st learning is by necessity shifting away from the individualistic acquisition of knowledge to interdisciplinary process and application of skills and creativity (Barell, 2007; Dean, Hubbell & Pitler, 2012; Harvey & Daniels, 2009; Kuhlthau, Maniotes & Caspari, 2007; Pahomov, 2014; www.p21.org). Problem-solving, research, analysis, interpretation, reasoning, creative thinking, communication and collaboration are the cognitive and social skills in demand in the workforce and post-secondary education. The shift away from No Child Left Behind and standardized test towards the Common Core and College and Career Readiness Standards reflects this new emphasis on understanding the concepts and larger questions of a discipline over knowing discrete facts. While testing remains a reality in today's classroom, the types of questions we are preparing learners to engage with are very different. In an information age, knowing and reciting large amounts of information is less important than being able to locate, evaluate, and use information and then apply it to new contexts (Kuhlthau, Maniotes & Caspari, 2007). This is evident in the CCR reading standards, which state, "to become college and career ready, students need to grapple with works of exceptional craft and thought whose range extends across genres, cultures, and centuries. By engaging with increasingly complex readings, students gain the ability to evaluate intricate arguments and the capacity to surmount the challenges posed by complex texts" (CCRS, 2013, p. 13). Although not all standards can be accomplished through inquiry units, most objectives are suited to the integrated inquiry approach when thoughtfully planned to coincide with complementary points. An integrated approach can accomplish more than trying to address each standard separately (Kuhlthau, Maniotes & Caspari, 2007). In fact, it is through integrated instruction and inquiry-based approaches that all content standards (academic, professional, and digital literacy skills) can come together and be practiced in meaningful ways by students in lessons and units.

Collaboration

Collaboration is a central part of inquiry-based learning. Collaboration is a 21st Century skill that technology is both enabling and demanding through multimedia group projects (Heide & Henderson, 2001) and is a prominent feature of the workplace, with individuals often collaborating from multiple locations simultaneously. Technology has extended our community and facilitated worldwide interdependence necessitating collaboration and effective communication skills. This social interdependence, a combination of cooperative, competitive, and individualistic efforts, can be viewed at all levels of human interaction including the classroom (Johnson & Johnson, 1989). While traditional educational teaching methods focused primarily on individualistic and competitive goal structures, a meta-analysis by Johnson & Johnson (1987) shows that working cooperatively promotes higher achievement than the other two more traditional learning experiences. Additionally, the structure of cooperative learning appears to promote greater competencies in critical thinking skills and collaboration skills and increase positive attitudes towards subjects and grading (Johnson & Johnson, 1989). Inquiry-based learning uses the methods of cooperative learning to enhance collaboration skills among learners. Intentional group structures that promote learning according to Johnson & Johnson (1987) include positive interdependence, face-to-face interaction, individual accountability for meeting group goals, interpersonal skills and group evaluation of the process to improve group effectiveness. In a recent research brief on collaboration by P21 (Plucker et al., n.d.), the authors consider collaboration from three perspectives; collaboration as a means to achieve specific outcomes, collaboration as its own outcome for the purpose of developing this 21st Century skill, and the most integrated view that collaborative and cognitive skills can be developed through practice and mastery of collaboration. As collaboration is highlighted in P21's framework (Partnership for 21st Century learning, n.d.) and Common Core Standards, there is a shifting focus on assessing student collaborative skills and the outcomes of collaborative problem-solving from a cognitive perspective.

In a collaborative learning environment, learners engage with each other in problem-solving, task completion or product creation. Although group work does not equal collaboration, collaboration can occur in physical and virtual groups. Collaboration involves social skills such as effective communication (Johnson & Johnson, 1987) and cognitive skills involved in learning exploration or application of class material whereby two or more learners focus on learning something together, search for solutions or create something together (Laal & Laal, 2012).

Inquiry-based learning through collaboration should not be the only method applied to student learning but it offers an alternative structure when the learning goals require problem-solving and or creative thinking to solve complex or conceptual tasks, or the social development of students (Johnson & Johnson, 1987; Plucker et al., n.d.).

However, inquiry-based learning will not be successful without first modeling and practicing collaborative skills such as effective communication, skills in building openness and trust, leadership skills, and controversy skills. In stating the obvious, putting students in a group and having them work together without providing them with the strategies to collaborate successfully would be ineffective and irresponsible teaching.

This classroom research examines how group members interact while working together to find solutions to a digital challenge. I consider how students engage and problem-solve together as they discover how to create a spreadsheet in Microsoft Excel and how their words and actions reflect their thinking. I want to know how group dynamics affected collaboration and critical thinking. In addition, I wish to investigate the levels of cognitive complexity involved in inquiry-based learning when applied to learning new digital skills. The present classroom study adds to needed area of educational research on collaboration, critical thinking, English language learners, adult education and the integration of technology.

Critical Thinking

Definitions for critical thinking are as wide ranging as the disciplines doing the defining. Philosophy tends to take a traditional western view of critical thinking as being a hierarchy of stages in complex rational thinking to which everyone has equal access. For the field of psychology and pedagogy, critical thinking is a critical literacy that gives the powerless access to the discourse communities of the powerful (Curry, 1999). However, there are common strands that tie these definitions together. Essentially, critical thinking is an awareness of one's own thinking, biases and reasoning that is informed by the world and open to change (Foundation for Critical Thinking, 1999;

Mezirow, 1997; Thayer-Bacon, 2002). Critical thinkers constantly analyze, assess and upgrade their thinking. Creative thinking and problem-solving are natural by-products of critical thought. Critical thinking is central to learning because learning is a transformation of previous thinking as new concepts are introduced. Critical thinking does not occur in a vacuum of the mind, but is very much informed by a person's experience with the world (Mezirow, 1997; Thayer-Bacon, 2002).

In a society that is transforming at rapid speed, the ability to think critically about one's environment and adapt accordingly is crucial. How are these skills taught to adults who already have very strong frames of reference for thinking and interacting with the world? In order for adults to fully participate and thrive in a rapid changing world, they must become autonomous, socially responsible thinkers (Mezirow, 1997). It is the role of the educator to help learners become aware of and be critical of their own and others assumptions and engage in discourse that allows for new information to be incorporated into their frame of reference. Learners will not arrive here alone by merely working with a partner. They must be taught how to participate as a critical thinker.

Other researchers also hold this view that critical thinking is strengthened by interactions with differing perspectives, which can only happen in the context of social interaction (Mercer, 1995; Thayer-Bacon, 2002). This social paradigm of critical thinking is an important perspective to consider as this inquiry collects evidence of critical thinking occurring in a social context. This approach places the teacher in the role of facilitator rather than authority. Learners in the context of this study use language strategies and peer knowledge to reframe and transform new ideas about computer spreadsheets into existing schemas. Language strategies serve as a representation of the type of thinking involved in transformative learning.

Critical thinking has been identified as an essential skill for 21st Century life and is one of the transition skills for adult learners to move from ABE to the workplace and post secondary education (Parrish & Johnson, 2010). For the scope of this study, I will use the definition of critical thinking offered by the Transitions Integration Framework since it was written for the context and student profile of ABE and states, "In ABE classrooms, CT skills involve actively applying thinking strategies that range from analyzing relationships between components to drawing conclusions from a variety of data" (2013, p. 42). What are the effects of critical thinking strategies on students? Thinking critically deepens one's understanding of a concept or discipline because it asks us to reason and provide evidence for our thinking. Incorporating critical thinking into lessons requires teachers to be good critical thinkers themselves (Foundation for Critical Thinking, 1999).

While critical thinking is recognized as an essential transition skill by ABE standards, classroom research is needed to inform critical thinking instruction and integration. How do you create critical thinking opportunities for students to practice in the classroom? Due to the overall lack of research on technology instruction and transition skills instruction in ESL adult education, I hope to provide one model that shows how technology, critical thinking and collaboration skills may be integrated through an inquiry-based approach. In the current classroom research, adult learners participate in authentic inquiry that requires them to participate and work in groups to solve and redefine problems using technology. This current study considers critical thinking through student-centered peer collaboration where the shared task is inquiry-based. That is, what types of critical thinking occur when learners must collaborate together to find a solution, in this case how to create an Excel spreadsheet? A secondary aim of this study related to critical thinking is to consider the level of cognitive complexity involved in learning digital skills through the inquiry method.

Research Gap and Niche

Through this present study, I hope to offer one model for technology instruction that incorporates transition skills including critical thinking and collaboration. This study adds to an area of educational research on collaboration, critical thinking, English language learners, adult education and the integration of technology. Little research exists specifically in ABE on technology instruction using an inquiry-based approach. There is even less available research on the development of 21^{st} Century skills among adult English language learners. Professional development providers, such as ATLAS (ABE teaching and learning advancement system) in Minnesota, are seeking ways to help ABE instructors incorporate content standards, transition skills and technology into lessons. In order for Adult Basic Education to develop best practices for learner instruction that address multiple sets of standards, more research is necessary to inform the field of ABE instruction. The current practice involved in teaching technology to adult ESL learners often focuses on direct procedural instruction with little to no attention given to student inquiry and problem-solving through collaboration. Given the overall lack of research on technology instruction and transition skills instruction in ESL adult education, I provide one model that shows how technology, critical thinking and collaboration skills may be integrated through an inquiry-based approach. I examine how

ESL adult learners use technology as a tool to practice transition skills, and specifically, critical thinking skills in an inquiry-based environment. Furthermore, I investigate the cognitive complexity of the tasks involved in this approach to technology instruction.

Summary

In this chapter, current literature pertaining to the preparation of ABE adults for jobs and lives in the 21st Century was reviewed. Research on the current state of technology instruction in ABE was analyzed and a lack of studies was found on this particular group of learners in our education system. Finally, pedagogical research on guided inquiry as an instructional strategy was examined and a connection between critical thinking and collaboration skills as they relate to inquiry-based instruction was established. A current gap in research has been noted in regards to effective 21st Century skills instruction for the adult ESL community of learners. Technology integration through guided inquiry was considered as an optimal environment for active reflection and construction of knowledge. In chapter one, the purpose, significance and need for this study were discussed. Chapter three will describe the methodology applied to seek answers to the research questions.

CHAPTER THREE: METHODOLOGY

This study is designed to explore the relationship between an inquiry-based approach to learning, critical thinking and digital literacy integration in an advanced adult ESL classroom. This study examines how adult ESL students, some with limited schooling, are learning new technology skills through the structure of inquiry-based learning and collaboration. I wish to find out if critical thinking can be developed and practiced within the structure of inquiry-based learning when applied to learning new digital skills. It is my hope to add to the field of research on adult literacy and provide a model to better integrate computer literacy and 21st Century skills in adult literacy programs. The core research questions are as follows: *In learning digital literacy and technology skills via an inquiry approach, what types of critical thinking skills are utilized by learners? What level of cognitive complexity is involved in learning digital skills through inquiry-based learning?*

In this chapter, I explain the tools and data collecting methods used to answer the above questions. In order to examine and collect data that pertain to these questions, I designed a tool for demonstration of critical thinking specific to the context of inquiry-based learning using technology. Inquiry-based learning relies on 21st Century skills like collaboration and critical thinking in order to deepen knowledge, therefore, I wanted to develop a tool that accounted for these skills against the backdrop of well-established measurements that drive standards and intellectual rigor.

Method

In this research, learners from non-western countries were engaged in the construction of knowledge using authentic real-world activities. They brought different talents and experiences, and they had different levels and abilities for inquiry. Communication was analyzed between partners as they navigated unfamiliar terrain. It was important to understand this communication in the context of the lesson and how the language of reasoning is taught. In the dialogical approach to communication, students verbalize their thinking as they work through challenges. The qualitative nature of my study fits with classroom research models where learning is observed and recorded in its natural environment. Since the research investigates the relationship between inquiry, collaboration and thinking skills, this study describes the language used by participants in triads while they engage in technologically complex tasks. Data was categorized and analyzed based on verbal and non-verbal communication elicited through the problem-solving process on a computer. Observations and recording data were corroborated with student self-reflections that were developed by the teacher as part of the inquiry process. In order to prepare for data collection, the observation tool and recording device was first tested with a group of three students in the same classroom. The test group challenge was to use Google Docs to make a document, name the document, and print the document. Students had been introduced to Google Docs but their ability to use the program was still elementary. Partners had to problem solve through the steps in the challenge, which provided me with an optimal environment for using my observation tool.

As a result of this pilot, adjustments were made to the observation form such as separating critical thinking skills and communication onto two separate pages to allow more space for evidence documentation. The digital recording of the conversation between partners proved adequate. Additionally, the assistant observer listened to 15 minutes of the digital recording and wrote examples on the observation form of evidence of critical thinking and communication skills. The researcher and assistant then compared the observation notes and discussed types of evidence relevant to each sub category on the observation form. The assistant was provided with a copy of the updated observation form so that she could become familiar and comfortable with using the form in the study.

Participants and Location

The research was carried out in a single advanced adult ESL class in a non-profit adult learning center in the Upper Midwest. This class is part of the larger context of adult English Language Learners in Adult Basic Education using technology in the classroom. The class was comprised of sixteen learners with a CASAS range of 205-229 or a TABE score of 392-501. The languages represented in this class included Karen, Burmese, Nuer, Hmong, Spanish, Somali, Amharic, Arabic, Farsi, and Russian. Students ranged between the ages of 22 to 50 years old. Previous educational experience ran the gamut from no formal schooling to college degrees. This class met Monday through Friday from 9:15AM to 1:15PM, although inconsistent attendance was a frequent occurrence. The majority of the class was not required to attend school but students attended for personal and professional reasons. Those students that were required to attend school were receiving some type of government assistance that dictated they be enrolled in school for 20 hours per week with an additional 5 hours of employment related classes. This particular learning center located in the urban core of a large Metropolitan area in the Upper Midwest, also has Beginning Literacy, Beginning, and Intermediate ESL classes, a GED® class and Employment Readiness classes. Over the past program year, the learning center has served 365 low-income adults for a total of 74,098 contact hours. Additionally, there is an onsite preschool for the children of the adult students, which includes some of the students in this study.

This study took place over three consecutive days during the morning period with each period lasting approximately ninety minutes. During the first day, the teacher provided direct instruction of concept and vocabulary for the inquiry project as well as the scaffolding needed for successful student inquiry. On this day, the teacher established mixed groups based on differing technology and languages skills. This intentional grouping was designed to maximize peer knowledge when problem-solving through the medium of English. Five groups were created from the fifteen students present on the first day of the project. Two groups from this class were selected for data collection for this study based on the attendance reliability of the group members. Triad 1 consisted of participants with the first languages of Hmong, Spanish and Karen. Participants' previous schooling in this group ranged from finishing 6-8 years of education in their country of origin to a high school diploma from the United States. Two participants in Triad 2 spoke Karen and one participant spoke Spanish as a first language. Similarly, previous education in this group ranged from 6-8 years of formal schooling in their home country to some high school in their home country. Student inquiry took place over two days lasting approximately 90 minutes each day. Group participants remained consistent with the exception of one participant from Triad 1 who was absent on the final day of inquiry. In the event of unforeseen problems, a third triad was set up with a digital recorder but ultimately was not needed for data collection.

Table 1. Student Demographics of Triad Participants

Group	Language	Age	Previous schooling from home country
Triad 1			
Student O	Hmong	38	High School diploma
Student D	Spanish	41	6-8 years
Student M	Karen	34	9-12 years
Triad 2			
Student N	Spanish	28	10 years
Student G	Karen	29	High School diploma
Student C	Karen	29	6-8 years

Data Collection Tools

To create context and build background for my research, the researcher observed the lesson through the pre-inquiry period of prior knowledge activation and concept and vocabulary introduction, a necessary step for successful inquiry in this context. The first lesson was dedicated to preparing learners through direct instruction in order to build concepts and provide language for the next phase of student collaboration. The second and third lessons involved the more complex collaborative task of learning how to organize data in an Excel table without explicit instruction from the teacher. For the computer group activity, the trained volunteer from the pilot study observed one student group while the researcher observed the second triad to ensure thorough documentation. In the observation, groups sought ways to organize data in an Excel spreadsheet during which time both their verbal and non-verbal interactions were examined for signs of critical thinking. Group dialogue was also recorded and analyzed at a later date for evidence of critical thinking. Recordings were transcribed and coded according to the skills and sub skills defined in the Transitions Integration Framework (see Appendix A)(ATLAS, 2013). At the close of the study, student written reflections were collected for additional insight into student experience and thinking.

In developing the critical thinking observation tool (see Figure 2 below), the types of activities that learners would need to complete the inquiry task was considered. The observation tool was based on a matrix developed by Karen Hess for assessing science inquiry (Hess, 2006). Given the nature of the computer inquiry project in this study, the structure of learning follows a similar course to science inquiry. Hess created a matrix that combined Andrew Porter's cognitive demand categories for science with Norman Webb's Depth of knowledge. The observation categories are based on examples of inquiry tasks at each stage of the inquiry cycle on the matrix. The researcher also consulted with the classroom teacher on her lesson design in preparing learners to take a more independent inquiry role. In order to measure student thinking, the researcher designed two sections of the observation form; the first section demonstrates actions in the inquiry process that reflect critical thinking. The second portion of the form includes effective communication where thinking may be shared verbally (see Figure 2). Since the inquiry task included problem solving and communication objectives, both criteria were built into the observation tool. Inquiry-based learning emphasizes collaboration and critical thinking during the process of acquiring and deepening knowledge and understanding (Audet & Jordan, 2005; Kuhlthau, Maniotes & Caspari, 2007). Both the critical thinking and communication section examples may overlap with each other as the thinking process in this collaborative environment is demonstrated through speaking and action. The observation form includes critical thinking behaviors necessary in the problem solving process such as activating and drawing on prior knowledge, deciding on a procedure and evaluating consequences. These stages of inquiry are reflected in Hess' matrix for science assessment (Hess, 2006) and in the sub skills of the critical thinking category on the TIF (ATLAS, 2013). Specifically, skill 2 on the TIF is the ability to solve problems and includes sub skill 2e where students are able to identify, prioritize, and apply steps to solve problems and sub skill 2d, identify and evaluate potential solutions and possible consequences of those solutions. In addition, the communication category is broken into sub-categories of effective group communication including asking a partner questions, respectively agreeing or disagreeing, and sharing ideas for how to proceed. For each sub-category of critical thinking and communication on the observation form, there is a place to record examples of specific behaviors (see Figure 2 below).

A small digital recorder was also used with each student group because audio recordings allowed for student discourse to be analyzed in greater depth at a later time and served to support the observation data. The third tool used for data collection was a student written reflection (see Appendix C). Teacher-created post-lesson student reflections were collected at the end of the project to measure student thinking and corroborate data. The student reflection tool was a series of five questions for students to evaluate what and how they had learned during the computer project. The questions asked students about the most important ideas they learned, where they can use these new ideas, what new question they have, how they helped their group and how their group helped them. The last fifteen minutes of class on the final day of the project was allocated for students to answer these questions. These reflections provided the researcher with first hand accounts of the students' perspective on their learning experience.

Considering data through different lenses provides opportunities to explore the relationship between levels of cognitive processing resulting from collaborative inquiry with technology and critical thinking skills used by triads to build knowledge. Data was further corroborated with teacher-created student self-reflections, adapted by the teacher from Barell (2007, p. 125), on the inquiry process. This provided insight into student thinking and reflection, an important step in inquiry-based instruction and critical thinking: How did I help my partner? How did my partner help me? What were the most important ideas we learned? Where can we use these new ideas? What new questions do we have? Analysis of data considers the role of collaboration during the inquiry process by adult English language learners and whether this collaboration shows evidence critical thinking skills by having partners verbalize and express their thought process.

CRITICAL THINKING OBSERVATION FORM

DATE_______________ DYAD____________Recorder # _______

CRITICAL THINKING SKILLS	EXAMPLES
Ss use prior knowledge to make connections and observations (can Ss identify the pre-taught concepts and vocabulary?)	
Ss decide on a procedure (not randomly clicking)	
Ss evaluate the consequences (is this the desired outcome?)	

CRITICAL THINKING OBSERVATION FORM

DATE_______________ DYAD____________Recorder # _______

COMMUNICATION	
Ss ask partner questions	
Ask the teacher a question that is specific to the problem. (Not “what’s next?”)	
Ss listen to partner	
Ss respectively agree or disagree (use language like “I don’t agree __ because” or “I don’t think so because ____”	

Figure 2: Critical Thinking Observation Form

Procedure

Data were collected by various qualitative methods in order to explore the research questions from different perspectives. These methods included group observations, audio recordings of student groups, and written student reflections on the project. Data were initially collected from group observations using the Critical Thinking Observation form, which was designed to look for steps in the inquiry process that show evidence of critical thinking and communication. The observation format was chosen because it allowed tracking of both non-verbal and verbal interaction in student groups. The observation form included a place to record examples of behaviors in order to provide evidence within the context of the activity (see figure 2). The second method of data collection was through audio recordings, which allowed for student discourse to be analyzed in greater depth. A digital recording device was placed at each computer to record verbal interactions between students. At the end of the study, student written reflections were collected from the class as part of the triangulation of data. This project took place over three consecutive days for three class periods, each lasting approximately one and a half hours.

To place the data collection in context, the researcher and assistant observed the first lesson of the project where the teacher introduced the inquiry project, lesson objectives and the project timeline (see figure 3 below for lesson plan). The conceptual objectives that guided this project were as follows: 1) Describe the purpose of a spreadsheet. 2) Give examples of types of information that spreadsheets are intended to organize. 3) Appropriately organize and label information in rows and columns. During this introductory lesson, key vocabulary were also introduced and taught including row, column, cell, data, and heading. Learners were organized intentionally into mixed-ability groups of three to discuss classroom demographic data from five different learning centers. Groups were instructed to sketch out on paper a table that showed the demographic data for 5 learning centers with appropriate headings. At this stage, the teacher provided some scaffolding by listing the larger heading categories such as age. However, groups needed to decide how to include data for sub categories of age. Despite various approaches to organizing and categorizing, all groups were able to organize data into a table. This first lesson concluded with a class discussion on the benefits of organizing data into a table and students speculated on the merits of using a computer to create tables.

Day two of the project began with a review of the purpose of organizing information into tables as well as a review of vocabulary introduced on day one. The word “spreadsheet” was introduced at this time along with the purpose of spreadsheet programs like Excel. The teacher reviewed with the class the philosophy for group technology work and the class discussed strategies for working on the project such as talking with each other, asking questions, giving a lot of ideas, making sure everyone understands, and sharing the work including data input and formatting. In addition to preparing learners for Excel, the class practiced language for asking for ideas and giving suggestions including, “What do you think we should do?” and “I think we should . . .” Only after concept review and language practice did groups use the computer. Students worked in groups of three that were set up the previous day. Each group had a laptop and group members helped each other figure out how to find Excel, open the application, and create a spreadsheet with the information from their paper table generated on day one. Groups were encouraged to check with other groups if they got stuck. The teacher also circulated and provided "just in time" skills when groups asked questions specific to a problem such as "we don't know how to erase the line." Day three was set for project completion and reflection. Groups continued to work on the Excel spreadsheet, formatting and discovering how to use the AutoSum function. There was an extension option of creating a graph from the data for groups that finished early. The last fifteen minutes of class was dedicated to individual student reflections on their thinking during the project.

Three triads were chosen, based on their heterogeneous languages and consistent attendance. This insured that communication between partners would be in English and that group members would stay consistent over the three-day project. Two triads were observed closely and a third triad was audio recorded as insurance for any unforeseen problems with the first two triads. I recruited and trained a volunteer to observe one student group while I observed the second triad to ensure thorough documentation. To ensure inter-rater reliability, the assistant observer and I went through our observations after each lesson and compared data for each category of the observation form. Each triad was simultaneously being recorded for each of the two inquiry sessions totaling nine hours of recordings. However, only two of the triads' recordings, totaling 6 hours of data, were analyzed for critical thinking.

THE BASICS			
Project Title	Excel – Organizing Data in Spreadsheets		
Developer	Jessica Jones	**Class**	Advanced ESL
Time Frame	3 x 90 mins.	**Learner Levels**	Lvl. 5-6
Task	Translate reports on classroom demographic data into an Excel spreadsheet		

ESSENTIAL PROJECT ELEMENTS	
Conceptual Objectives:	• Describe the purpose of a spreadsheet • Give examples of types of information that spreadsheets are intended to organize • Appropriately organize and label information in rows and columns
Skill Objectives:	• Open and save Excel spreadsheets • Enter text into cells and determine which cells the information is actually in • Adjust row and column width • Format text in cells • Create row/column totals using "sum" formula • Identify appropriate statistical information in charts and reports • Use comparative and superlative phrases to ask about and express conclusions about data
Communication and Problem-Solving Objectives	• Offer and ask for suggestions • Evaluate the effectiveness of what they tried • Check for errors by comparing the data with what they already know
Key Words and symbols	• Spreadsheet • Row/column/cell • Data • Heading
Lesson Plan – Day 1	
Project Launch & Warm-Up	• Introduce lesson objectives and schedule for the week. • Small group discussion questions (see attachment in Appendix C)
Activity 1	• Introduce task: create an Excel spreadsheet with information about the students in 4 different schools. In groups of 3, sketch out an empty table with appropriate headings and space for data. • Learners highlight relevant data in the MNABE reports and fill their chart paper. • Groups compare results with other groups.
Whole Class Discussion	• Discuss: The impact of inverting rows and columns. • Why organize information in a table? • Why type this table in Excel? • What could we do next?
Language extension	Practice comparative and superlative language using data in their paper tables. (see Appendix C)
Lesson Plan – Day 2	
Warm-Up	**Review**: • Items from Day 1 • Task: 1) Enter your data in Excel. 2) Format your table. Make it

	beautiful and print. 3) Total each of the columns • Purpose of organizing information in a table • Vocabulary: *row, column, heading, cell* • **Introduce** *spreadsheet.* Introduce the purpose of spreadsheet programs like Excel
Activity 1	• Restate philosophy for group technology work. • Together create a list of rules/strategies for working together on today's project • Practice language for offering/asking for suggestions (see Appendix C)
Activity 2	Get computers for group work time Teacher support "Just in Time" skills: Formatting headings and related data, using AutoSum to create totals, checking data for errors *(does this make sense?)*
Lesson Plan – Day 3	
Warm-Up	**Review:** • Items from yesterday • Task
Activity 1	Group work time to finish & print Excel spreadsheet Teacher support "Just in Time" skills: Formatting headings and related data, using AutoSum to create totals, checking for errors *(Does this make sense?)*
Extension Challenge	Create a pie graph that shows the percentage of students from each country in our school
Wrap-up & Reflection	Individual and whole class reflection (see Appendix C)

Figure 3: Microsoft Excel Lesson Plan Overview

Research Data Analysis

The analysis comprises of qualitative measures of critical thinking skills and cognitive complexity through observations and recordings of student inquiry activities and behavior. The study involved observing and recording triads of adult students learn how to create and organize information on an Excel spreadsheet over two consecutive class periods with no prior direct instruction for using the application. The observation instrument included sections for observable critical thinking skills and communication skills. The observation tool was designed with the inquiry processes in mind and the sections for critical thinking and communication reflect typical patterns of inquiry such as “decide on a procedure” and “evaluate consequences”. Observed participants were also audio recorded in order to provide a more detailed account of the observation data. At the conclusion of the study, student self-reflections were collected and examined through the lens of critical thinking.

Data was collected over two days and observation notes from both groups were thoroughly read and compared. Audio recordings were analyzed to confirm and expand upon observation data. The audio recordings were transcribed for each group in order to provide more detailed data then the observations could provide alone. The observations allowed for more general impressions and context, which supported the details in the audio recordings. In this way, the observations provided an initial impression of patterns in the data such as polite language and tone used for agreeing and disagreeing, turn taking on the keyboard and strategies used for formatting that were demonstrated rather than verbalized. Coding of the transcriptions was done based on the Transitions Integration Framework’s (TIF) critical thinking category and sub categories (see Appendix A). The TIF’s critical thinking category was chosen as an analytical framework because it was designed for adult basic education learners and defines critical thinking skills in terms considered essential for the workplace, career training and postsecondary education. From these recordings, student speech was checked against the group observations for consistency and as part of the first round of data analysis. Data collected from the audio recordings were coded and categorized into the following critical thinking skills as laid out by TIF (2013): 1) Organize, analyze and illustrate relationships between components, items, and ideas; 2) Solve problems; 3) Use information to draw conclusions and make decisions. The fourth skill, recognize bias, assumptions and multiple perspectives, was not relevant to this particular project. Data were then further broken down into sixteen sub skills across the four critical thinking skill areas (Appendix A).

Additionally, the resulting data from the critical thinking analysis were overlaid with Webb's Depth of Knowledge framework (Hess, 2013) in order to show complexity of learning (see Appendix B). The observable intersection of critical thinking skills and the Depth of Knowledge provides a more complete understanding of the cognitive complexity of the various stages of inquiry and higher order thinking as defined by TIF and captured by observations and recordings. Finally, participant self-reflections from the study groups were read and compared with the whole class responses. Student reflections provided added insight into student thinking and experience regarding the class project. Students provided feedback on their experience through a series of five questions that asked students to evaluate what and how they had learned during the computer project (see Appendix C). The results of this study show the types of critical thinking generated between students as they problem-solve how to create a spreadsheet with specific information using the Excel application. Considering learning from an additional angle, this study also shows the levels of cognitive complexity involved in this type of inquiry task.

Summary

In this chapter, a detailed description of the data collection tools and methods used in this paper was provided. The research methods employed for this qualitative research study include analysis and categorization of student group interactions and activities captured through observations, digital recordings, and student self-reflections. A rationale was presented for using the specific instruments for the purpose of data collection given the research questions and context. The chapter also gives a brief overview of the participants in this study and setting in which data was compiled. Procedures for data collection were laid out and an analysis of the data was provided. The results of this study will provide insight into the dynamic relationship of student collaboration during an inquiry process. I will consider the types of critical thinking generated between students as they work together to use a new computer software program, and the cognitive complexity that such a task demands. In chapter four I present a detailed analysis and data commentary.

CHAPTER FOUR: RESULTS

In order to offer more examples of technology and 21st Century skills integration in the ABE classroom, this study was designed to look at how critical thinking and digital literacy come together within the context of inquiry-based learning. It is my hope that the results from this classroom study may add to the field of research on adult literacy and provide a model to better integrate computer literacy and 21st Century skills in adult literacy programs. The core research questions are as follows: *In learning digital literacy and technology skills via an inquiry approach, what types of critical thinking skills are utilized by learners? What level of cognitive complexity is involved in learning digital skills through inquiry-based learning?* Data for this study were collected via the qualitative approach through observations, audio recordings, and student self-reflections collected during regular classroom time. In this chapter, I present the findings of the audio recording, observation and self-reflection data with reference to the first question when analyzed using the critical thinking framework of the TIF. I then present the findings of the data as they relate to the second question using Webb's Depth of Knowledge framework.

Findings

Types of Critical Thinking Skills

Let us consider the first research question: *In learning digital literacy and technology skills via an inquiry approach, what types of critical thinking skills are utilized by learners?* The cooperative structure used for this computer assignment necessitated that group members verbalize their ideas with one another, which consequently gave me utterances that revealed learners' thinking.

Audio recordings. The audio recordings from the two triads were transcribed and then coded according to the types of critical thinking sub skills as defined by the Transitions Integration Framework. After initial coding of the two study groups, a similar pattern of critical thinking skills emerged. Coding showed that Triad 1 had 8 examples of critical thinking skill 1, organize, analyze and illustrate relationships between components, items, and ideas. Triad 1 showed 42 occurrences of skill 2, solve problems, and 16 of skill 3, use information to draw conclusions and make decisions. Similarly, Triad 2 showed 3 examples of skill 1, 32 of skill 2 and 18 of skill 3. Due to their similar patterns, it was determined that the results from both groups would be combined from here on out and analyzed as a data set. The results can be seen in Table 2, Table 3 and Figure 4. Table 2 compares the number of occurrences of critical thinking skills recorded between Triad 1 and Triad 2. Table 3 shows the combined number of occurrences of critical thinking skills and sub skills from both triads. Figure 4 represents the data from Table 3 in order of descending frequency.

Table 2. Comparison of Critical Thinking Occurrences

Comparison of Triad Results	Triad 1 # of occurrences	Triad 2 # of occurrences
Critical Thinking Skill 1 Organize, analyze and illustrate	8	3

relationships between components, items, and ideas		
Critical Thinking Skill 2 Solve problems	42	32
Critical Thinking Skill 3 Use information to draw conclusions and make decisions	18	17

Table 3. Critical Thinking Skills Frequency Table

Sub-skills	CRITICAL THINKING	# of occurrences
	Skill 1: Organize, analyze and illustrate relationships between components, items, and ideas	
1a	Sequence components, items, or ideas in a logical or structured manner (e.g., alphabetical, chronological)	7
1b	Categorize items or ideas and articulate rationale (positive vs. negative, fact vs. opinion)	0
1c	Synthesize information, ideas, and components in a meaningful and structured way	0
1d	Support positions using prior knowledge and supporting evidence	5
	Skill 2: Solve problems	
2a,b	Identify barriers to accomplishing a task or solving a problem/ Clearly articulate the component parts of a problem	13
2c	Identify information needed to solve a problem	14
2d	Identify and evaluate potential solutions and possible consequences of those solutions	25
2e	Identify, prioritize, and apply steps to solve problems	22
	Skill 3: Use information to draw conclusions and make decisions	
3a, b	Articulate criteria for decision making as it pertains to a specified goal or purpose/ Identify information needed to accomplish a task or meet a purpose	7
3c	Evaluate the quality and validity of information (new reports, gossip, online resources)	7
3d	Identify and evaluate options and consequences	21
	Skill 4: Recognize bias, assumptions and multiple perspectives	0

Adapted from Transitions Integration Framework, 2013

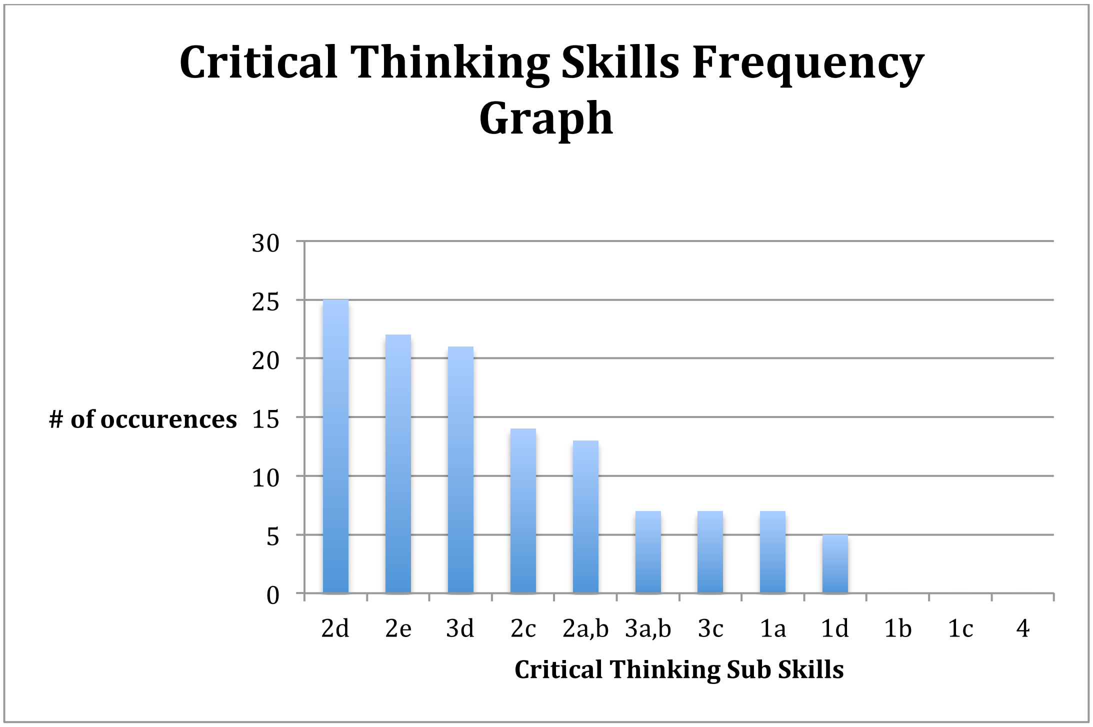

Figure 4: Critical thinking skills frequency bar graph

Skill 2: Critical thinking skill 2, the ability to solve problems, is where students spent 62% of their time during this inquiry-based project (see Figure 5 below). There were a total of seventy-eight instances altogether. During this phase of the learning, critical-thinking sub skill were coded as follows. When students used each other or the teacher as a resource for when they had questions about how to proceed, this was coded as sub skill 2a and b. In this phase of problem-solving, students were identifying and articulating the barrier to accomplishing a task. For sub skill 2c, the student is searching for specific information to solve the problem. Students using this sub skill were often identifying information and giving directions to their group members. For example, when a group wanted to change the color in several cells, one of the students gave directions on how to click and "slide," highlight text, and select colors. Examples such as this were coded as sub skill 2c. As group partners "encouraged one another to take risks, try options, evaluate outcomes and try new procedures if necessary," data were coded as sub skill 2d. This positive encouragement seemed to add to group persistence in tackling obstacles. Coding for sub skill 2e was based on students "identifying and prioritizing steps" and often included words such as "first and "after". For example, utterances such as, "we already did the first column. You need to try a second and third column" were coded as 2e.

The highest incidence of all critical thinking sub skills in skill 2 appeared in sub skill 2d, "identify and evaluate potential solutions and possible consequences of those solutions." With twenty-five examples in this sub skill category, it appears to be a critical part of the problem-solving process and builds on the previous problem-solving sub skills. In order to move forward in the problem solving process, one needs to consider alternative solutions to barriers that arise. Students in this study discussed various ways of moving forward, even if they weren't sure of the correct solution. A reoccurring utterance from students was "try" or "I think we can try first." Before continuing I wish to differentiate this sub skill from the very similar sub skill, 3d, "identify and evaluate options and consequences." During the problem-solving process, students would take risks, try options and evaluate the results. Sometimes they needed to try multiple times in order to solve the problem. For example, when a group wanted to delete a column, they right-clicked and looked at their options. They first chose "cut" but when nothing happened they tried "delete." In contrast, sub skill 3d pertains more to the evaluation of decisions based on known information, i.e., discussing color options.

Students have already discovered how to change cell color and are now evaluating color choices and the effect of various colors on the table's appearance.

Talking through one's thinking solidifies the procedural approach of problem solving for the speaker and provides the other group members with a good example of problem-solving strategies. The very nature of working with others in a group necessitated verbalization of ideas, which deepens thinking. This could be witnessed in the following group, which was trying to add a border around the table. G says, "Right now we gonna find a line we gonna make a box. I know, I know, we have to try one by one. Yes! We got it! Border, border, Oh we got it now." C: "What are you doing, I don't know?" G: "Why did this work and the 2 border is not work? I should delete this." The group laughs together trying options and eventually calls on a student from another group to help. This collective problem-solving made the process fun and productive as was evidenced in the laughter and positive outcomes. It could be inferred that the high incidence of the critical thinking sub skill 2d, "identify and evaluate potential solutions and possible consequences of those solutions," is a natural outcome of task-based learning. Students were interacting with a computer software program that provided a wide selection of tools and choices and consequences for choices made were immediate. It was the group that was responsible for choices and consequences not the teacher. Task based inquiry learning as seen in this study places the student at the center of their learning as thinkers, solvers, and creators.

Sub skill 2e, "identify, prioritize, and apply steps to solve problems," also had a high frequency of observed occurrences; there were twenty-two instances. This sub skill was well distributed throughout the two-day group project as students reminded each other of most important steps to focus on first such as entering data, mastering AutoSum, and making the table “beautiful.” Students repeatedly used terms such as, “go step-by-step”, “first . . . and then”, and “try one by one.” Observing such language shows that students were constantly reminding each other of the steps for including important elements in the table. Identifying, prioritizing, and applying steps also helped students break down tasks into smaller, more manageable chunks. G: “Right now we gonna find a line we gonna make a box. I know I know, We have to try one by one. Yes! We got it!” Groups also had to determine the order of steps based on importance. In one group, one student wanted to add color to the table but her partner thought that they should total the columns using AutoSum first. They finally decide of the order of steps. M: “How about if we add the all numbers first and then we can put the color?” D: “Ok.” M: “It’s better.” This example shows how one student was able to help the other student prioritize steps in order of importance. Understanding the steps to solving a problem and then prioritizing and acting based on this understanding is an important skill necessary in solving problems.

Critical thinking skill 2a, “identify barriers to accomplishing a task or solving a problem,” was observed when the group realized they could not find solutions together and sought solutions from other groups or the teacher. “Teacher we don’t know remember how we can save.” This skill was predictably associated with skill 2b, “clearly articulate the component parts of a problem,” as students needed to articulate the barriers as they sought help from each other, other groups or the teacher. Since these processes are tied so closely together and move seamlessly together, sub-skill 2a and 2b are considered together. Combined, these sub skills accounted for thirteen instances of critical thinking. Common barriers for groups occurred around formatting and font size. Students were encouraged to ask specific questions when they were stuck rather than "what's next." When groups had trouble articulating their precise problem, the teacher continued to ask leading questions until they arrived at the problem. One group asked the teacher:

> "We need help. We need to move the line." Teacher: "You want to connect those 2 cells?" Student: "Ya." Teacher: "Highlight the 2 cells you want to connect." Student: "I don't know why this is color change." Teacher: "Well those are 2 different problems. Which problem do you want to do first?" Student: "I think change the yellow to the normal." Teacher: "Now look up here at your toolbar. Do you see anything that is yellow right now?" Student: "Oh." Teacher: "Yeah, see that little can that's got the yellow? Change that one back to white." Student: "OK."

From this dialogue, the student first identified and articulated two different problems (sub skill 2a and 2b) and after prioritizing the problems was able to find the information needed to solve the problem (sub skill 2c). Sub skill 2c, "identify information needed to solve a problem," is also closely associated with the ability to identify and articulate problems but is now moving into identifying viable options to solve the problem. This critical thinking sub skill was noted fourteen times over two days. For example, one group wanted to make a border around the table. One of the group members stated, "right now we gonna find a line we gonna make a box . . . we have to try one by one." The student identified what information was needed to find a solution and they were successful in creating a border. Students using this skill had moved beyond articulating the problem and were now looking for information to solve the problem.

When groups were really stuck, they would consult with students from other groups. In one exchange, the students discussed how to select multiple cells in order to change the font size. M: “Do you know how to highlight?” Questions like this were coded as sub skill 2a and b. D: “We try together. We try together. Calm down. Ok?” (laughing). M: “How about if we highlight and pull change the number?” This student is identifying potential solutions and was coded as sub skill 2d. D: “Ya, hold on, we need the big letter first. Hold on ok. It’s ok? Or more is. It’s ok?” M: “Uh huh.” At this point, the partners are evaluating the consequences of the solution tried, and was also coded as sub skill 2d.

Further examples coded as sub skill 2a, 2b and 2c are as follows. In order for groups to move forward and overcome barriers in the problem-solving process, they needed to identify and articulate the precise problem so they could receive the help they needed either from each other, other groups or the teacher. In this way, groups first tried to troubleshoot together before asking other groups for help. A student from a group would often go to other groups to seek answers when they were stuck, demonstrating sub skill 2 a and b. When they returned to teach the other group members, they were using sub skill 2c as they identified the information to solve the problem. One group realized they needed to total the columns but didn’t know how so they sent a group member to another group to learn. Students were aware of the specific problem but didn't yet know the information they needed to solve the problem. Examples such as this were coded as sub skill 2a and b. Upon returning, this student directed the group to find the information to use AutoSum, which is evidence of critical thinking sub skill 2c.

The above confirms the claim that inquiry-based instruction is centered around problem-solving. The teacher was there as a resource when all other routes had been exhausted. Part of the problem-solving process is identifying barriers, articulating the issue and identifying the information needed to move forward. Groups demonstrated these skills each time they encountered a new issue and working through this process enabled the group to move into other stages of problem-solving such as evaluating potential solutions to problems. Indeed, the very tasks for this classroom project involved students discovering how to create an Excel spreadsheet with all its critical information using problem-solving strategies such as teamwork, making decisions based on observations and prior knowledge, evaluating consequences and options, and seeking alternate solutions. Evidence of problem-solving was noted throughout this project as students investigated how to create a spreadsheet on Excel with only basic concept knowledge of tables. Without direct instruction, students problem-solved how to open and save Excel spreadsheets, enter and format text into cells, adjust row and column width, and create column totals using "sum" formula. Students used critical thinking to navigate through this process for the first time, as they used and showed reasoning, planning and evidence to solve non-routine problems.

Skill 3. The third skill of critical thinking listed in the TIF is the ability to "use information to draw conclusions and make decisions." There were a total of thirty-five instances in this study. In this category, students evaluated the quality of the spreadsheet and based on evidence, tried other options to create a table with all the necessary components. Groups also evaluated the effectiveness of what other students had tried by sending scouts to other groups to see if they had solved challenges such as AutoSum. During this phase, students make decisions and draw conclusions based on known information or evidence, i.e., discussing color options or font size. Common language heard in this phase included "I think we should," "you (are) right," "how about," "is that correct," "what do you think?" Critical thinking skills were coded in the following way: Sub skills 3a and b were combined for reasons similar to sub skills 2a and b where "identify" and "articulate" were expressed the same way in the context of collaboration. An example of coding in this sub skill involved students giving feedback on choosing a name for their spreadsheet. As names were suggested, one student helped the group decide on a shorter title, "not too long." Sub skill 3c was coded based on students' monitoring of errors and spelling during data entry. Formatting and visual appeal discussions were coded as sub skill 3d.

Sub skill 3d was second only to sub skill 2d for largest number of occurrences of all critical thinking sub skills at twenty-one. It appears that the process of creating something new, in this case an Excel spreadsheet, inevitably necessitates that students identify and evaluate options and consequences. Group participants had to work together and evaluate choices particularly around appearance. There was much discussion around formatting where the results of solutions tried were immediately apparent. Students played with font size evaluating the effects. "How about 24?" D: "Ya." (Laughing). M: "Too big!" M: "How about 18?" D: "Better?" M: "Ya, better." M: "I think we should change all the same." D: "Ok, ya. I try ok?" This type of discussion also occurred around color choices for the table. N: "What about if you make that pink? Do we have pink color?" G: "green?" N: "Pink." G: "Pink." N: "I think that one is too dark." G: "The blue one blue blue." C: "Blue?" G: "Ya." C: "Uh uh, it's really dark." N: "Really dark." G: "Ya, really dark, so it's not clear. So you want to change the color?" N: "Uh huh." It appears that this type of computer project is rich in opportunities to try different solutions and evaluate results of choices. Furthermore, it is worth noting that decision-making regarding options and consequences appeared more regularly in the second part day one and throughout day two of the computer project. Students had learned how to complete most of the essential elements of the spreadsheet and were now concerned with spacing, cell size, font size and overall visual appeal.

Sub skills 3a and 3b will be considered together as both are closely related in the context of group work and have a lower occurrence rate, occurring seven times. In the context of collaboration, sub skill 3b, "identify information needed to accomplish a task" and 3a, "articulate criteria for decision-making" are interwoven. Group members must articulate what they identify as information needed to accomplish a task. In groups, students were forced to communicate their ideas regarding the table content and layout. In fact, the teacher had provided students with language for asking and giving suggestions during the introductory stage of the project. One of the expectations for all students was that they would contribute their ideas and opinions during the project. Students talked through decisions for choosing a name for the Excel file so they could find it again the next day. One student also wrote down the file name in her notebook to help her remember the following day. In applying these skills, students also needed to recall known information to accomplish tasks or would ask other group members if they knew how to accomplish a specific task. One student asked her partner if she knew how to erase so that they could move ahead with their data entry. This shows the student was able to identify and articulate what needed to be done first in order to accomplish the task of data entry (sub skill 3a and 3b).

Sub skill 3c, "evaluate the quality and validity of information," applied to the quality control exercised by group participants during the data entry phase. There were seven instances of this sub skill. Group participants helped each other with spelling and accurate number entry as well as heading and sub heading placement. This element of the project did not play a large role as students were not involved in evaluating sources of data but rather entering data correctly.

During this study, students engaged in critical thinking skill 3, use information to draw conclusions and make decisions, 28% of the time (see Figure 5 below). In creating a new spreadsheet in Excel with all the necessary information included, students had the opportunity to make formatting decisions that increased the visual appeal and readability of their product. Students were able to identify and articulate for partners options and ideas regarding the layout of the Excel spreadsheet. A significant portion of the time in this skill was spent evaluating the consequences of choices made particularly regarding color and cell space. This type of project naturally builds in student choice, and empowers learners by giving them control over their learning.

Skill 1. Critical thinking skill 1 is defined as being able "to organize, analyze and illustrate relationships between components, items, and ideas." This skill is then defined by four sub skills. Only two of these were used for data analysis, 1a and 1d for a combined occurrence of twelve instances. Sub skills 1b was not observed as it involves students articulating their rationale for categorizing items. While students in this study did articulate how they should categorize items, they did not provide as rationale for why they should do it. This was due to the nature of the task rather than students inability to perform this skill. The objectives of this project did not ask students to categorize by value judgments such as positive versus negative or provide a rationale for their ideas. Similarly, sub skill 1c, synthesize information, ideas, and components in a meaningful and structured way, goes beyond the scope of this project. While students in the study did structure components in a meaningful way, they were not required to synthesize information from multiple sources.

In skill 1, the most frequently used sub skill observed was skill 1a, "the ability to sequence components, items, or ideas in a logical or structured manner (e.g., alphabetical, chronological)." It was discussed seven times. The following scenarios that showed categorizing and organization of data were coded as sub skill 1a. During the process of creating a table and then an Excel spreadsheet, students had to choose how they would organize their information in a computer format. Both groups decided to enter all the vertical and horizontal headings first before they added the numbers. There was also discussion on how and where to add sub headings. In one exchange, a student remarked how they needed to go step-by-step entering information. Throughout this project, students also consistently checked to make sure that data were entered in the correct cells.

Sub skill 1d is the other sub skill under skill 1 that was coded, "support positions using prior knowledge and supporting evidence." For this computer project, students checked for errors by comparing the data with prior knowledge and used pre-taught vocabulary to support their positions. For example, one student reminded the others of what the teacher suggested, "Teacher said the heading we should put the capital letter." The students used vocabulary introduced prior to the computer assignment during the Excel project such as "row", "column", "erase", "highlight", "print" and "save." These words were essential to effectively communicating with their group about the assignment. On the second day of the computer project, students recalled information needed from the previous day, "Do you remember how we started yesterday we go to the Microsoft, Microsoft Excel?" So in this unit of instruction, the inquiry-based approach provided opportunities for students to demonstrate the critical-thinking skills of how to complete their tasks in a logical, methodical fashion as well as use prior knowledge and supporting evidence, both which fall into skill 1, sub skill 1a and 1d respectively.

Although critical thinking skill 1 only represented 10% of the type of thinking that students engaged in, it provided basic foundational thinking necessary for organizing and classifying information. Recalling new vocabulary to apply to the task at hand was critical for communicating ideas in order to problem-solve and make decisions later on. Similarly, the step by step approach to organizing data provides the foundation for the more complex task of critical thinking sub skill 2e, prioritize and apply steps to solve problems.

Skill 4: It should be noted that critical thinking skill 4, recognize bias, assumptions and multiple perspectives, was not relevant to lesson objectives or the tasks involved in the classroom project. Therefore, there were zero occurrences of this skill observed. For sub skills defined under this skill, please see Appendix A.

In sum, the data shows that the process of inquiry and subsequently problem-solving in this computer project is reflected in the way students move through critical thinking skills as they work through a challenge in an unfamiliar computer environment. These cycles of inquiry during the project occurred 11 times for Triad 1 and 12 times for Triad 2. This was rather predictable given the nature of the task and the cycle of learning. The complexity of creating a table using an unfamiliar computer program created a rich opportunity for students to use critical thinking and problem-solving strategies such as collaboration, peer support, and risk-taking. The level of complexity of this challenge powers the cycles of critical thinking and learning. Although groups did not tackle challenges exactly the same way, they did follow similar patterns in thinking and all arrived at a final product that met the criteria laid out by the teacher. For example, students relied on each other for ideas, confidence to take risks, and encouragement. As they moved through the project, groups moved back and forth between problem-solving, decision-making, and organization of material using prior knowledge. In fact, as the most prominent critical thinking skills in this project were problem-solving and consequently decision-making, and since one relies on the other to move forward, we can consider a cycle of inquiry to start with problem-solving and then move into decision-making.

Cognitive Complexity

Using Karin Hess's *A guide for using Webb's depth of knowledge with common core state standards* (2013), I will attempt to provide an answer to the second question; *What level of cognitive complexity is involved in learning digital skills through inquiry-based learning?* As stated previously, Webb's depth of knowledge (DOK) has four levels of cognitive rigor that relate to the complexity of mental processing involved in a task (see Appendix B). As tasks move from level 1 through the next levels, they become increasing more complex and rigorous. Level 1 tasks are the building blocks for more cognitively rigorous tasks in levels 2, 3, and 4. Figure 5 below represents the percentage of occurrences of critical thinking skills 1 through 3 and the corresponding DOK levels they represent. The number of occurrences of sub skills under each skill were combined and calculated as a percent of the total number of skills. Sub skills were combined under each skill category because even within a sub skill there was DOK variance. Critical thinking skill 2, solve problems, represented 62% of the data. As problem-solving correlates with a DOK level 3, clearly student spent the majority of the project engaged at this level of cognitive complexity. Critical thinking skill 3, make decisions and evaluate options, made up 28% of the critical thinking data and represented both a DOK 2 and 3 as was determined by the complexity of the task. Critical thinking skill 1, organize information and use prior knowledge, represented 10% of the total data displayed in Table 3. The cognitive complexity of the critical thinking skill 1 included both DOK 1 and 2 depending on the task involved (see Appendix B for skills demonstrated in this study).

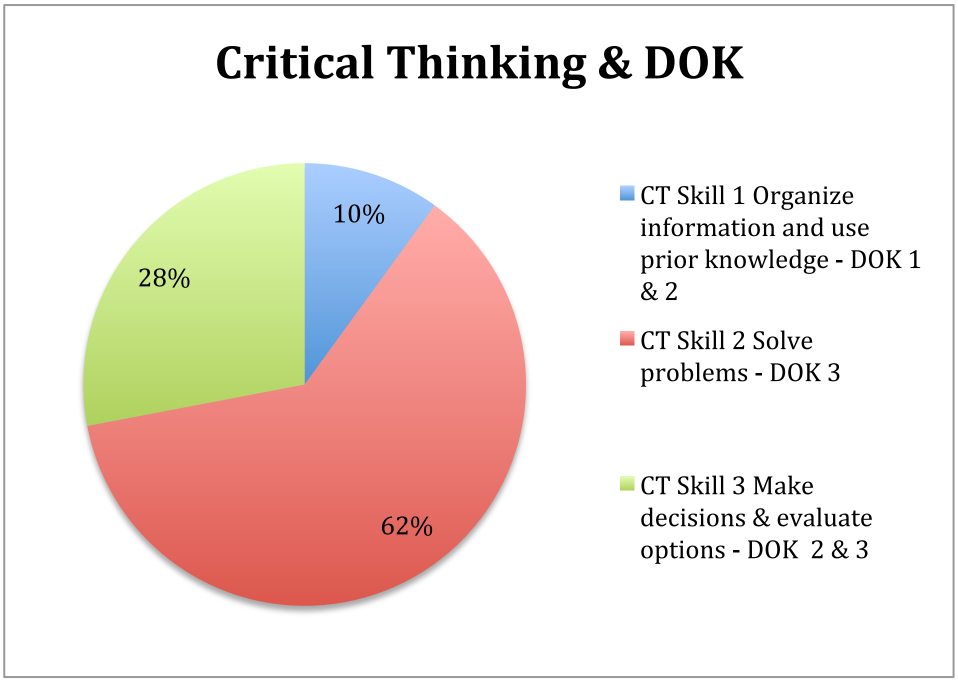

Figure 5: The Correlation of Critical Thinking Skills & Depth of Knowledge

DOK level 3: Strategic Thinking and Reasoning. The most significant findings relating to depth of knowledge in this study was the rate of occurrence of critical thinking skills that are at DOK level 3. DOK level 3, strategic thinking and reasoning, is the level where more complex thinking occurs and involves the integration of conceptual knowledge and skills to solve real world problems. Students spent 62% of their time using critical thinking skill 2, problem-solving a novel task. Data from this study shows that students spent the majority of their time in the problem-solving phase as they learned how to create and format an Excel spreadsheet for the first time (see Figure 3). Using concepts to solve non-routine problems is an example of a task that falls into this DOK level. Problem-solving involves a series of complex tasks as learners need to understand and use concepts to solve problems as well as analyze and evaluate multiple outcomes throughout the process. Critical thinking skill 3, make decisions and evaluate options, was a DOK 3 task when students were evaluating options to fit the whole spreadsheet onto a single page. "How do we move more (to fit on 1 page)? We can put American on top and Indians down (vertical instead of horizontal)." When solutions are not straightforward, students are forced to explain their thinking to the group (DOK 3). During this project, students moved through a process that resulted in a product containing all the criteria set by the teacher. In doing so, they used and showed reasoning, planning, and evidence (DOK 3) as they described, compared and contrasted solution methods (DOK 3). Since problem-solving activities are clearly at a DOK level 3 and since problem-solving is also central to inquiry-based learning, it is evident that inquiry-based learning provides ample opportunities for students to engage in DOK level 3 activities.

DOK Level 2: Skills and Concepts. The next most significant rate of occurrence of critical thinking skills falls into DOK level 2. Students were working at DOK level 2, "skills and concepts," as they were organizing and displaying data in a table on day one and later transferring the same information onto the Excel spreadsheet. Critical thinking skill 1 moves into a DOK 2 in the task of categorizing and organizing data on the spreadsheet as students decide on how to proceed in creating the table. One group settled a name first and then entered headings. Critical thinking skill 3, use information to draw conclusions and make decisions, fell into DOK level 2 when decision-making was straight forward. For example, making observations about font size or spacing, "I think every single word need two space." Since DOK level 2 and 3 are directly related to the sophistication of GED® test questions (GED® Testing Service, 2015) and CCRS anchors (Pimentel, 2013), it is significant that students engaged in this inquiry-based project spent

90% of their time working at a DOK level 2 or 3. Consequently, this study shows that instructional models such as the inquiry-based model are cognitively rigorous and meet the standards set by the field of ABE.

DOK Level 1: Recall and Reproduction. Level 1 is "recall and reproduction" of knowledge and represents the automaticity necessary for the next level of cognitive processing. This DOK level was coded as having been demonstrated by students by using instances of critical thinking skill 1: Organize, analyze and illustrate relationships between components, items, and ideas. Checking for spelling errors based on recall of vocabulary is such an example of critical thinking skill 1d at a DOK level 1. Similarly, a student reading out the headings for columns for a partner's data entry is an example of skill 1a in a DOK 1. These tasks correspond to the ability to recall, observe and recognize facts, principles, and properties and identify if specific information is contained in graphic representations as cited in Hess DOK matrix (2013). While student activities are not as cognitively demanding at this level, they provide foundational support to concept development needed for the higher levels of DOK. For example, recalling new vocabulary specific to the computer challenge (DOK 1) allowed for students to articulate and communicate their ideas with the group in order to do more complex tasks like identify, prioritize, and apply steps to solve problems (DOK 3).

DOK Level 4: Extended Thinking. DOK 4 is not addressed in this study as it involved critical and creative thinking and reflection over an extended period of time. Although there is potential for creating an authentic, extended project, this was not the objective for this particular classroom project.

In sum, the complexity of cognitive processing that students are performing in this computer project ranges from a level one to a level three with the majority of the time spent on problem-solving in level three. Integration of technology, teamwork, and problem-solving creates opportunities for students to enhance a diverse set of skills including critical thinking. In contrast, the traditional computer-instruction model of teaching a checklist of skills where students demonstrate proficiency through a multiple-choice format demands only a DOK 1. When activities are cognitively rigorous, learners have the opportunity to process learning more deeply and thereby retain concepts and skills. Students are actively involved in their learning through hands-on tools, in this case computers, and group collaboration. Through this project, there is evidence that students are engaging in cognitively complex tasks through the inquiry-based approach to learning technology.

Discussion

This study adds to the area of educational research on collaboration, critical thinking, English language learners, adult education and the integration of technology. It is intended that this study will provide ABE instructors with research that supports the integration of content standards, transition skills and technology into lessons. Little research exists specifically in ABE on technology instruction using an inquiry-based approach (Lesgold & Welch-Ross, 2012b). There is even less available research on the development of 21st Century skills among adult English language learners (Lesgold & Welch-Ross, 2012a). This study suggests that it is possible to integrate technology, critical thinking, collaboration, and communication skills in the limited class time of adult ESL

Integrated technology and ABE Standards

Adult Basic Education in the last decade has become standards driven in preparing learners for the workforce, higher education, training and civic engagement (ATLAS, 2015). As our society has shifted to a post-industrial knowledge-based workforce, ABE is tasked with preparing adults with skills that address academic, career and technology preparedness (Parrish & Johnson, 2010). These skills are addressed with the College and Career Readiness Standards (CCRS), the Transitions Integration Framework (TIF) and the Northstar Digital Literacy Standards (NSDL). It is obvious that with so many standards to consider and very limited class time teachers need to create lessons that address multiple standards at the same time. And yet much of the research involved in teaching technology to adult ESL learners focused on direct procedural instruction during "computer time" with little consideration for integrating other skills such as critical thinking (Northstar Digital Literacy Project, 2014). However, there is simply not enough time in a typical ABE class to teach technology in isolation from lessons nor is it advised to do so. If we consider that digital literacy requires both cognitive and technical skills to find, evaluate, create, and communicate information (ALA Digital Literacy Taskforce, 2011), then it is imperative that we give learners opportunities to practice such skills. To date, there is a lack of research-based models on integrating technology into adult basic education (ABE) lessons specifically designed for adult English language learners (Lesgold & Welch-Ross, 2012b). These results suggest that it is possible to integrate technology skills with critical thinking skills in the collaborative environment of inquiry-based instruction. Considering the categories of the TIF, the findings from this study show that this inquiry-based model seamlessly integrated the category of critical thinking into technology instruction (Kuhlthau, Maniotes & Caspari, 2007). The results indicate that a variety of critical thinking skills, primarily problem-solving, are employed by adult ESL learners when they learn technology skills via the inquiry method.

However, ABE instructors are also required to increase the rigor of lessons by incorporating CCRS academic standards in addition to Northstar digital literacy skills and TIF skills. This project aligned with the CCR speaking and listening strand anchor 5, "Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations" (Pimentel, 2013, p. 32). Students were given the task of not only entering the data into their spreadsheet, but also to "make it beautiful." There was much discussion in groups regarding the presentation of data using color and font size. Two groups in the class had completed all the criteria for creating a spreadsheet and as an extension had also made a pie chart to express the data. Regarding the Northstar Digital Literacy Standards (NSDL), this project has met the majority of standards for Microsoft Excel (Northstar Digital Literacy Project, 2014). However, where NSDL assessments are as cognitively complex as level 1 depth of knowledge (DOK 1), this study shows that it is possible to design lessons that require a level 2 or 3 depth of knowledge. This project does not claim mastery by students of all the skills within a module like Excel. Instead, the study shows an alternative way of teaching technology skills while also integrating other skills and standards in a more meaningful way. As stated by the CEO forum, "technology can have the greatest impact when integrated into the curriculum to achieve clear, measurable educational objectives" (the CEO Forum on Education and Technology, 2001, p. 4). Through the inquiry-based model used in this study, it is evident that when technology is used as a tool to create, solve problems, and think critically it incorporates more standards and rigor and provides students with a richer learning experience.

Inquiry-Based Learning and Collaboration

The instructional model used by the teacher for the class project in this study is inquiry-based learning. Although this is not the only method used in this classroom, it is the one chosen by the teacher for this particular type of project because of the opportunities to solve an authentic problem, collaborate in groups, and engage in hands-on activities. Inquiry-based learning challenges students to work with peers to solve a challenge/problem (Kuhlthau, Maniotes & Caspari, 2007). Through this approach, students use each other as a resource to collectively solve a problem or create something novel. However, inquiry-based learning can only be successful after first addressing some of the foundational components of this approach. If the content is new to the learners, then the basic skills and concepts needed for the project must be directly taught first (Audet & Jordan, 2005). Day one of the study was focused on concept building around expressing data in tables with discussion questions, guided practice, language for discussing tables, and group expectations. This set the students up for success during the student-centered phase of the project when students were collaborating in groups to create an Excel spreadsheet. Students were given the language to discuss tables and data entry such as “row”, “cell,” “column,” and “heading.” More importantly, they were given language and strategies for working in a group. Since collaboration is considered a 21st Century skill and is highlighted in P21’s framework (Partnership for 21st Century learning, n.d.) and CCRS (Pimentel, 2013), it is necessary to discuss the impact of collaboration on the findings.

The data collected for this study indicated that group members interacted with each other and the computer program as they worked collaboratively on their group project through hands-on inquiry. By being placed in groups, students had to articulate their thoughts, ideas, and questions in order to complete the project. This structure not only provided the researcher with data on student thinking but also the social environment of the groups. These findings are consistent with research which claim that collaboration involves both social skills such as effective communication and cognitive skills, whereby two or more learners focus on learning something together, search for solutions or create something together (Johnson & Johnson, 1987; Laal & Laal, 2012). The explicit teaching and practice of collaboration skills allowed for more productive problem-solving as ideas were shared and participants encouraged each other to take risks and try options (Johnson & Johnson,1987). The results show that students spent 62% of their work time together engaging in problem-solving. This collaborative environment encouraged risk-taking as students had the safety net of the group, other groups and the teacher. Students used positive language to encourage one another such as, “let’s try again,” “all students keep going,” “no you got it wrong try again,” and “we do it together.” Also noticeable from the audio recordings were the frequency of students affirming each other’s ideas in problem-solving and decision-making. They were clearly all in it together. This supportive culture was also reflected in the laughter as groups worked on formatting and AutoSum. One student summarized a common sentiment expressed in the written reflection: “My group helped me when they share their ideas about something I didn’t know and when we took turns to complete our work together.” In response to the reflection question on how I helped my group, responses were similar; "I help them to type and give some of my ideas." This positive attitude towards collaboration arises from the philosophy of group work that the teacher has built in over a period of time. By creating a culture of collaboration in the classroom, new students who join the class are naturally incorporated into the classroom culture. On the first day of this project, the teacher reviewed what good and bad group communication looks like. During the group project, students assumed the responsibility of communicating with their partners and using positive language.

Positive group dynamics are an essential part of successful collaboration, which in turn lays the groundwork for critical thinking and problem-solving (Audet and Jordan, 2005; Kuhlthau, Maniotes and Caspari, 2007; Barell, 2007). The findings from this study support the research on the positive outcomes of inquiry-based instruction in the ESL classroom when learners are provided with a shared common experience, hands-on activities are built in, prior knowledge is activated, peer collaboration is modeled and practiced, and focused language teaching experiences are meaningfully incorporated into the lesson (Audet & Jordan, 2005). The results indicate that through inquiry students were successful in expressing critical thinking with each other as they learned technology skills to create an Excel spreadsheet.

Inquiry-Based Learning and Critical Thinking

How can one create critical thinking opportunities for students to practice in the classroom? In the current classroom research, adult learners participated in authentic inquiry that required them to participate and work in groups to solve and redefine problems using technology. Authentic real world situations, such as create or pull data from a spreadsheet at work, are highly engaging and motivational for students and provide opportunities to practice real-world skills like collaboration and critical thinking (Hmelo-Silver, Duncan and Chinn, 2007; Kuhlthau, Maniotes & Caspari, 2007). After all, many skills that are addressed in ABE standards are skills that are in demand in the workforce (Parrish & Johnson, 2010). By providing authentic learning experiences in the safety of the classroom, students can develop and practice these skills in a supportive environment. Technology is the ideal conduit to engage in authentic learning tasks as all the tools for problem-solving are right there in the program or device. And while technology can aid the development of critical thinking skills, the ability to think critically can aid learning of new skills such as technology skills (Thayer-Bacon, 2002; Mercer, 1995).

In this study, the teacher challenged students with a project that they might encounter in the workplace; translate reports on classroom demographic data into an Excel spreadsheet. Around this task, she designed lessons that included conceptual, technology skills and communication and problem-solving objectives. Students were expected to offer and ask for suggestions, evaluate the effectiveness of what they tried, and check for errors by comparing the data with what they already know. Such a project supports the technology standards from *International Society for Technology in Education* (2007), which include communication and collaboration, critical thinking, problem-solving and decision making, and technology operations and concepts. According to these ISTE standards, students are expected to use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.

The findings from this study show that students worked collaboratively to plan and create an Excel spreadsheet and include all the criteria laid out by the teacher by the set deadline. All groups were successful in meeting the criteria and some groups even continued on to the extended challenge of graphing the data. Students used group members' ideas to overcome barriers, take risks and make informed decisions based on observations, prior knowledge and evidence. This supports other researchers' views that critical thinking is strengthened by interactions in a social context (Thayer-Bacon, 2002; Mercer, 1995). Thinking critically deepens one's understanding of a concept or discipline because it asks us to reason and provide evidence for our thinking. When students work together in groups, they are forced to articulate their ideas, offer alternative suggestions, make observations, and support their positions based on evidence. Students modeled good thinking and reasoning skills for others in the group as they worked through problems. For example, one student helped her partners prioritize steps and tackle problems as they arose. This social environment enhanced the learning experience of the students involved, providing an ideal opportunity to practice and observe critical thinking.

If critical thinking deepens one's understanding of a concept and is strengthened by social interactions (Mercer, 1995; Plucker et al., n.d.; Thayer-Bacon, 2002), one could conclude that students' understanding of spreadsheets and tables was deepened as a result of using critical thinking skills with their peers throughout this inquiry-based project. Based on the results of this study, students engaged in a variety of critical thinking skills, which included solve problems, make decisions and evaluate options, and organize and analyze information. The complexity of these mental processes varied with the task and the results suggest that problem-solving was the most consistently complex of all the critical thinking skills in this study. Cognitive complexity was measured by Webb's Depth of Knowledge (DOK) levels (Webb, 2002). Problem-solving was assigned a DOK level 3. Depth of knowledge indicates the cognitive rigor of a task and reflects how deeply students know the content. A DOK level 3 indicates an in-depth integration of conceptual knowledge and multiple skills to reach a solution or produce a final product (see Appendix B)(Hess, 2013). Since students spent at least 62% of their time at a DOK level 3, it would imply that students in this study developed a deep understanding of technology skills relating to Excel spreadsheets.

Conclusion

In this study, I have presented one model for technology instruction that incorporates transition skills including critical thinking and collaboration. In this chapter, I presented the results of my study and the significance of the findings as they relate to the literature. Critical thinking data were organized and presented according to the skill and frequency of occurrence. Data was presented towards an answer to my research questions from group observations, audio-recordings of students and written reflections. In Chapter Five, I will discuss the implications of the study on Adult Basic Education and English language learners, consider the shortcomings of this study, and suggest the direction of future research.

CHAPTER FIVE: DISCUSSION

In the previous chapter, I presented my findings as they related to the two driving questions of the study, which are as follows: *In learning digital literacy and technology skills via an inquiry approach, what types of critical thinking skills are utilized by learners? What level of cognitive complexity is involved in learning digital skills through inquiry-based learning?* In answer to the first question, I reported on the results based on the types of critical thinking skills that were utilized by adult students working collaboratively on a computer project. Critical thinking was measured by coding verbal interactions of group members using the Transitions Integration Framework's critical thinking skills category. Data were quantified by frequency of occurrence for each sub skill of critical thinking. In response to the second question, critical thinking data were examined using Webb's Depth of Knowledge (DOK) scale to measure the cognitive complexity of the tasks involved in the study. Results indicated that learners using this model of inquiry while learning technology used a variety of critical thinking skills but most frequently engaged in problem-solving and evaluation skills. As students were engaged in the critical thinking of problem-solving and evaluation, they were cognitively processing at a DOK of 2 and 3. Since DOK levels indicate how deeply students understand content, it may be inferred from the results that students developed a deep understanding of tables and Excel spreadsheets by engaging in collaborative inquiry. I will now consider the shortcomings of this study, discuss the implications of this study on Adult Basic Education and English language learners, and suggest the direction of future research.

Limitations

Firstly, the small sample size of this study does not permit generalizability. However, this leaves the door open for future research with larger sample sizes. This study could be replicated with additional observers recording data from up to five triads within one class. For this study, data were collected from two groups of students with each group consisting of three students. On the third day of the study, one member from the first group was absent, leaving a group of two students. While this did not negatively affect the data, it was one less participant contributing to the project on the final day. Absenteeism is common in the adult ESL classroom as personal issues often interfere with class attendance. The classroom teacher in this study purposefully created groups of three to cope with missing partners. An important element of inquiry-based learning is designing sturdy groups that maximize collaboration and successful group outcomes

Secondly, while the focus of this study was on critical thinking skills from the Transitions Integration Framework, there are opportunities to focus on other categories of the TIF such as self-management, learning strategies or effective communication. The collaborative model of the project created an environment for students to practice effective communication skills as they engaged "positively and actively with individuals in both one-on-one and team settings to accomplish goals" (ATLAS, 2013, p. 69). This was expressed as group members used polite language to agree, disagree, ask for and give suggestions, and acknowledge and affirm others. Students took turns using the computer so that everyone had a chance to work with the Excel program. Students consistently demonstrated effective communication skill 1e; participate, make contributions, and encourage the contributions of others in order to accomplish the shared goal of a team. Examples of student language include, "I think we need to" and " I think we should . . ." Also, "Do you agree?" A participant who knew how to do a task asked, "Can I try?" rather than just taking over the computer. These communication skills were intentionally shared with the class as one of the objectives for the project and students received a handout with language for asking for ideas and giving suggestions (see Appendix C). For collaboration to be successful, group work strategies around effective communication are essential. The teacher had built in opportunities to practice language around asking for and giving suggestions before groups worked independently. The class had also discussed the philosophy behind group technology work and gave examples of good group communication and bad group communication. This TIF category of effective communication also intersects with the CCR speaking and listening strand, anchor 1: "Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively" (Pimentel, 2013, p. 29). Students were actively engaged in discussions about the spreadsheet as they asked each other "what do you think?" or validated others suggestions, "We can try." Partners with more knowledge politely asked if they could show the others how to do something, "Can I show you how to erase?" Often group members worked together to evaluate their product or choose next steps. Clearly, collaboration skills need to be intentionally built, practiced, and integrated into lessons.

The nature of group work requires not only good communication skills but also language to articulate ideas relating to the group project and a positive environment where participants are willing to take risks and share ideas.

A third consideration is that this project took place over a short time period with data being collected on the second and third day of the three-day project. While the observations and audio-recordings yielded ample data for this study, a longer data collection period will increase the ability to extend its claims or generalizable to a larger population. For example, it would be useful to collect data from the same class over several more inquiry projects using technology. This would show patterns of critical thinking over multiple projects. Another possibility is to collect data for critical thinking skills and depth of knowledge levels during one extended project.

A final consideration regarding limitations of this study relates to the setting. This study took place in an advanced ESL class where learners had good communication skills in English and were able to talk through ideas and articulate questions. Therefore, the findings can only be considered as they relate to advanced ESL adult learners. The results of this may not be as informative for a beginning or intermediate adult ESL class. Additionally, this study would be more difficult to replicate in a beginning or intermediate level ESL class if data collection were to be in English. Furthermore, the teacher in this study is a master teacher with a background in technology instruction. She was comfortable using Excel and teaching just-in-time skills as groups needed. She was able to anticipate the conceptual knowledge, skills, and language that students would need to work in independent groups and built these objectives into her lessons. This particular teacher integrates collaborative projects regularly into her class time and has built a culture that supports risk-taking, ideas sharing, and peer mentoring. Many students had previously used the handout on asking for and giving suggestions. Such repeated practice and modeling strengthens students' collaboration and communication skills.

Implications for ABE

One of the goals for this study was to consider how technology could be used as a tool in a guided inquiry environment to develop collaboration and higher order thinking skills. As a practitioner, I was looking for models of best practice for teaching digital literacy skills within the constraints of the adult ESL class while also addressing content standards and transition skills. I wished to examine how educators could better integrate technology seamlessly into existing curriculum while addressing College and Career Readiness Standards and the soft skills of the Transitions Integration Framework. By examining one approach to integrated technology through the lens of critical thinking, I was able to find evidence that 21st Century success skills such as collaboration and critical thinking can be integrated with technology and Language Arts content. To restate the Partnership for 21st Century Learning's benchmarks for learner preparedness, students must be able to apply critical thinking, communication, collaboration, and creative thinking using technologies to engage in 21st Century themes like civic literacy (n.d.). ABE needs successful models for integrating these 21st Century skills into seamlessly and consistently into lessons. Inquiry-based learning is one such model. However, in order to make this model accessible to teachers in the field, there needs to be professional development support through workshops, study circles, and mentorship. There are multiple elements that are essential to successful inquiry-based learning and that require training and mentoring. These include:

- Plan student learning goals around a real world task/problem.
- Create a culture of collaboration with clearly defined roles and responsibilities, turn-taking, and peer support.
- Consider situational factors such as open enrollment by creating strong groups that can add or lose members.
- Teach and practice task-specific language as well as language for effective communication.
- Review project goals and group expectations regularly.

Future Research

Given the limited amount of research in general on adult literacy, there are ample opportunities to extend research in the field of instructional practices around critical thinking, technology integration and collaboration especially in regards to adult ESL learners. However, relating to the scope of this current study, there is room to explore the impact of critical thinking and collaboration on learning to use technology over an extended period of time and with a larger sample of students. Furthermore, I would like to see a longitudinal study that compares digital literacy skill development using the traditional method versus the integrated inquiry method. A comparative study of learner outcomes of technology instruction in a traditional lab setting versus an integrated approach would support best practices for technology instruction. ABE content standards call for the integrated use of technology in the classroom based on K-12 research yet there limited research on technology integration in the adult ESL context.

From another perspective, it would be interesting to consider how technology instruction is facilitated by peer collaboration in adult ESL. What conditions are necessary for adults to benefit from such collaboration in order to maximize learning? What does collaboration with technology look like at various levels of adult ESL? There is a need for more empirical studies on how collaboration may facilitate learning of digital literacy skills for adults at different English proficiency levels.

Finally, I would like to see research on the relationship between teacher technology skills and technology integration in adult ESL settings. Since integration of technology is clearly an expectation of the new standards being adopted by ABE, research needs to examine the current practice of technology integration in the adult ESL classroom and make recommendations for teacher technology support. Better understanding of how technology is being successfully integrated into lessons would be beneficial to teacher training and professional development opportunities. Similarly, teacher classroom practices and teacher attitudes towards technology would offer ample opportunities for further research.

If 21st Century Education is to prepare learners for an increasingly complex and interrelated global society, there must be a shift towards learner-centered education and creating creative thinkers. It is the responsibility of all educators to enable this fundamental shift in how and what we teach. What does this look like in the Adult Basic Education classroom? It means challenging our learners to think in new ways. It is no longer adequate to teach “functional” English from textbooks that follow the same predictable themes or have separate “computer time” to work on isolated skills. Instead, provide learners with opportunities to interact with peers and the community through engaging projects. Give them the tools to work in groups, wrestle with problems, respond to engaging issues, and use multi media for various purposes and audiences. Create a space that is safe for students to explore learning in an unfamiliar way, one that is student-centered and intellectually rigorous. This study shows that it is possible to address the specific needs of adult ESL learners while integrating technology skills, language, critical thinking and collaboration skills. Inquiry-based projects, as seen in this study, bring together so many skills necessary in preparing learners for college, careers and more meaningful community participation. And as educators, it is our challenge and duty to help our learners gain access to the possibilities this country holds.

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Appendix A: Critical Thinking Category of the Transitions Integration Framework, 2013

Critical thinking: Critical thinking (CT) requires disciplined thinking that is open-minded, rational, and informed by evidence in order to arrive at decisions or conclusions that go beyond factual recall. In ABE classrooms, CT skills involve actively applying thinking strategies that range from analyzing relationships between components to drawing conclusions from a variety of data. CT skills are increasingly essential for ABE learners to succeed in the workplace, higher education, and in navigating the complexities of 21st Century life.
Skill 1: *SWBAT...* Organize, analyze and illustrate relationships between components, items, and ideas <u>Sub Skills:</u> □ a. Sequence components, items, or ideas in a logical or structured manner (e.g., alphabetical, chronological) □ b. Categorize items or ideas and articulate rationale (positive vs. negative, fact vs. opinion) □ c. Synthesize information, ideas, and components in a meaningful and structured way □ d. Support positions using prior knowledge and supporting evidence
Skill 2: *SWBAT...* Solve problems <u>Sub Skills:</u> □ a. Identify barriers to accomplishing a task or solving a problem □ b. Clearly articulate the component parts of a problem □ c. Identify information needed to solve a problem □ d. Identify and evaluate potential solutions and possible consequences of those solutions □ e. Identify, prioritize, and apply steps to solve problems
Skill 3: *SWBAT...* Use information to draw conclusions and make decisions <u>Sub Skills:</u> □ a. Articulate criteria for decision making as it pertains to a specified goal or purpose □ b. Identify information needed to accomplish a task or meet a purpose

□ c. Evaluate the quality and validity of information (new reports, gossip, online resources) □ d. Identify and evaluate options and consequences
Skill 4: *SWBAT...* Recognize bias, assumptions and multiple perspectives Sub Skills: □ a. Recognize a speaker or writer's intent or purpose □ b. Identify and compare perspectives/points of view of self and others □ c. Identify and evaluate bias and assumptions of self and others □ d. Recognize bias in a variety of media (texts, broadcasts, blogs) and evaluate how it affects message and delivery

Appendix B: Math & Science Alignment to Bloom's Taxonomy (Hess, 2013)
(Activities in bold represent skills demonstrated in this study)

Revised Bloom's Taxonomy	**Webb's DOK Level 1: Recall & Reproduction** Curricular elements that fall into this category involve basic tasks that require students to recall or reproduce knowledge and/or skills. The subject matter content at this level usually involves working with facts, terms, details, calculations, principles, and/or properties. It may also involve use of simple procedures or formulas. There is little or no transformation of the target knowledge or skill required by the tasks that fall into this category. A student answering a Level l item either knows the answer or does not; that is, the answer does not need to be figured out" or "solved.
Remember Retrieve knowledge from long-term memory, recognize, recall, locate, identify	• **Recall, observe & recognize facts, principles, properties** • Recall/identify conversions among representations or numbers (e.g., customary and metric measures.
Understand Construct meaning, clarify, paraphrase, represent, translate, illustrate, give examples, classify, categorize, summarize, generalize, infer a logical conclusion (such as from examples given), predict, compare/contrast, match like ideas, explain, construct models	• Evaluate an expression • Locate points on a grid or number on a number line • Solve a one-step problem • Represent math relationships in words, pictures, or symbols • Read, write, compare decimals in scientific notation

Apply Carry out or use a procedure in a given situation, carry out (apply to a familiar task), or use (apply) to an unfamiliar task	• Follow simple procedures (e.g., recipe-type directions) • Calculate, measure, apply a rule (e.g., rounding) • Apply algorithm or formula (e.g., area, perimeter) • Solve linear equations • Make conversions among representations or numbers, or within and between customary and metric measures
Analyze Break into constituent parts, determine how parts relate, differentiate between relevant-irrelevant, distinguish, focus, select, organize, outline, coherence, deconstruct	• Retrieve information from a table or graph to answer a question • **Identify whether specific information is contained in graphic representations (e.g. table graph, T-chart, diagram)** • **Identify a pattern/trend**
Evaluate Make judgments based on criteria, check, detect inconsistencies or fallacies, judge, critique	Not Applicable
Create Reorganize elements into new patterns/structures, generate, hypothesize, design, plan, produce	• Brainstorm ideas, concepts, or terms related to a topic

Revised Bloom's Taxonomy	**Webb's DOK Level 2: Skills & Concepts** Level 2 includes the engagement of mental processing beyond recalling, reproducing, or locating an answer. This level generally requires students to compare or differentiate among people, places, events, objects, text types, etc.; apply multiple concepts when responding; classify or sort items into meaningful categories; describe or explain relationships, such as cause and effect, character relationships; and provide and explain examples and non-examples. A Level 2 "describe or explain" task requires students to go beyond a basic description or definition to predict a possible result or explain "why" something might happen. The learner makes use of information provided in context to determine intended word meanings, which tools or approach is appropriate to find a solution (e.g., in a math word problem), or what characteristics to pay attention to when making observations.
Remember Retrieve knowledge from long-term memory, recognize, recall, locate, identify	Not applicable
Understand Construct meaning, clarify, paraphrase, represent, translate, illustrate, give examples, classify, categorize, summarize, generalize, infer a logical conclusion (such as from examples given), predict, compare/contrast, match like ideas, explain, construct models	• Specify and explain relationships (e.g., non-examples/examples, cause-effect) • **Make and record observations** • Explain steps followed • Summarize results or concepts • **Make basic inferences or**

	logical predictions from data/observations • Use models (e.g., diagrams to represent or explain mathematical concepts) Make and explain estimates
Apply Carry out or use a procedure in a given situation, carry out (apply to a familiar task), or use (apply) to an unfamiliar task	• Select a procedure according to criteria and perform it • Solve routine problem applying multiple concepts or decision points • Retrieve information from a table, graph, or figure and use it to solve a problem requiring multiple steps • Translate between tables, graphs, words, and symbolic notations (e.g., graph data from a table) • **Construct models given criteria**
Analyze Break into constituent parts, determine how parts relate, differentiate between relevant-irrelevant, distinguish, focus, select, organize, outline, coherence, deconstruct	• **Categorize, classify materials, data, figures based on characteristics** • **Organize or order data** • Compare/contrast figures or data • Select appropriate graph and organize & display data • Interpret data from a simple graph • Extend a pattern
Evaluate Make judgments based on criteria, check, detect inconsistencies or fallacies, judge, critique	Not Applicable
Create	• Generate conjectures or hypotheses based on

Reorganize elements into new patterns/structures, generate, hypothesize, design, plan, produce	observations or prior knowledge and experience

Revised Bloom's Taxonomy	**Webb's DOK Level 3: Strategic Thinking & Reasoning** Tasks and classroom discourse falling into this category demand the use of planning, reasoning, and higher order thinking processes, such as analysis and evaluation, to solve real-world problems or explore questions with multiple possible outcomes. Stating one's reasoning and providing relevant supporting evidence are key markers of DOK 3 tasks. The expectation established for tasks at this level require an in-depth integration of conceptual knowledge and multiple skills to reach a solution or produce a final product. DOK 3 tasks and classroom discourse focus on in-depth understanding of one text, one data set, one investigation, or one key source, whereas DOK 4 tasks expand the breadth of the task using multiple texts or sources, or multiple concepts/disciplines to reach a solution or create a final product.
Remember Retrieve knowledge from long-term memory, recognize, recall, locate, identify	Not applicable
Understand Construct meaning, clarify, paraphrase, represent, translate, illustrate, give examples, classify, categorize, summarize, generalize, infer a logical conclusion (such as from	• **Use concepts to solve non-routine problems** • Explain, generalize, or connect ideas using supporting evidence • Make and justify

examples given), predict, compare/contrast, match like ideas, explain, construct models	conjectures • **Explain thinking when more than one response/solution is possible** • Explain phenomena in terms of concepts
Apply Carry out or use a procedure in a given situation, carry out (apply to a familiar task), or use (apply) to an unfamiliar task	• Design investigation for a specific purpose or research question • Conduct a designed investigation • **Use concepts to solve non-routine problems** • **Use and show reasoning, planning, and evidence** • Translate between problem & symbol notation when not a direct translation
Analyze Break into constituent parts, determine how parts relate, differentiate between relevant-irrelevant, distinguish, focus, select, organize, outline, coherence, deconstruct	• Compare information within data sets or texts or across related data sets • Analyze and draw conclusions from data, citing evidence • **Generalize a pattern** • Interpret data from complex graph • Analyze similarities/differences between research procedures or solutions
Evaluate Make judgments based on criteria, check, detect inconsistencies or fallacies, judge, critique	• Cite evidence and develop a logical argument for concepts or solutions • **Describe, compare, and contrast solution methods** • Verify reasonableness of results

Create Reorganize elements into new patterns/structures, generate, hypothesize, design, plan, produce	• Synthesize information within one data set, source or text • Formulate an original problem given a situation • Develop a scientific/mathematical model for a complex situation

Revised Bloom's Taxonomy	**Webb's DOK Level 4: Extended Thinking**
	Not Applicable for this study

Appendix C: Excel Lesson Plan Handouts

Comparing Data – Comparative & Superlative Adjectives

Look at your table to find the answers. Write your answers in complete sentences.

Example: Which school has the largest number of students?
Lake School has **the largest** number of students.

1. Is the number of Latino students **smaller** or **larger than** the number of Black students at Eagle school?
2. Which School has **a lower** number of Asian students, Pine or Birch school?
3. Which age group is **the smallest** at all the schools?
4. Which school has **the highest** number of Latino students?
5. Why do you think your school has so **many** Asian students?
6. Why do you think there are **more** women **than** men enrolled at all the schools?

Asking for and Giving Suggestions

Asking For Ideas

- What do you think we should do?
- What else could we try?
- Any ideas?

- What are we trying to do?
- Do you see anything here that might help us?

Giving Suggestions

- I think we should . . .
- I don't think we should . . .

- Maybe you should . . .

- I think we need to . . .
- I don't think we need to . . .
- Maybe we need to . . .

- What if we . . .
- Why don't we . . .
- How about if you . . .
- See what happens if you . . .

Name ____

Evaluate my Thinking

1. **What were the most important ideas we learned?**
   What words or ideas did you learn about tables and spreadsheets? What words or ideas did you learn about Microsoft Excel?

2. **Where can we use these new ideas?**
   Name 3 types of information that you could organize in an Excel spreadsheet.

3. **What new questions do I have?**
   What else do you want to know about Microsoft Excel?

4. **How did I help my group?**

5. **How did my group help me?**

Adapted from Barell (2007, p. 125)