Summer 2021

Using Graphic Organizers and Spreadsheets to Increase Quantitative Literacy Skills in High School History Students

Bruce Alexander Thames

USING GRAPHIC ORGANIZERS AND SPREADSHEETS TO INCREASE QUANTITATIVE LITERACY SKILLS IN HIGH SCHOOL HISTORY STUDENTS

by

Bruce Alexander Thames

Bachelor of Science
US Military Academy, 1981

Master of Business Administration
Boston University, 1986

Master of Educational Administration
Scranton University, 2009

Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctor of Education in

Curriculum and Instruction

College of Education

University of South Carolina

2021

Accepted by:

Ismahan Arslan-Ari, Committee Chair

Lucas Vasconcelos, Committee Member

Hengtao Tang, Committee Member

Anna C. Clifford, Committee Member

Tracey L. Weldon, Interim Vice Provost and Dean of the Graduate School

DEDICATION

I dedicate this dissertation work to my wife Janet, who has been unwavering in her support for me in this endeavor and allowed me the space to engage in it fully, often at the expense of family, church, and social activities; to my three children and their spouses Justin, Ashley (Kevin) and Erin (Jordan) for offering support, feedback and technical assistance during this process; and to the newest loves of my life, my granddaughter Annie Ruth and grandson Finn, who have only delivered smiles and the promise for a bright future. To my colleagues in the Suburban School District, thanks for listening to my presentations during staff development and for providing feedback. Thanks to Cohort Vader and my writing group, Lisa and Jeff, for all your invaluable help. Thanks to the many USC professors and staff who have made this a most satisfying experience, especially Dr. Grant, Dr. Morris, and Dr. Arslan-Ari who have provided tremendous expertise and advice during this three-year adventure.

ACKNOWLEDGEMENTS

The guidance provided by the staff and faculty of the Department of Education and the members of my committee have supported my personal and professional growth for the past two years. This support gave me the opportunity to learn many new lessons, provided me access to a whole world of educational topics I was unaware of and helped me to examine my own beliefs about the role that education, research and technology plays. I truly appreciate the hours of review and encouragement, feedback and perspective on my ideas and their guidance through this process.

ABSTRACT

Students are leaving high school and college with insufficient Quantitative Literacy (QL) skills to fully understand lifelong decisions about citizenship, personal finances, and healthcare. These quantitative skills are not taught consistently across the curriculum, which prevents students from making connections across multiple courses and correctly applying math skills beyond the classroom. The purpose of this action research was to evaluate the effectiveness of graphic organizers, spreadsheets, and authentic data on the QL skills of 11th grade students enrolled in an honors level United States History class enrolled at a suburban NJ high school (SHS).

This study focused on two overarching research questions. 1) How does the implementation of the use of advanced graphic organizers and the use of a spreadsheet tool to manipulate authentic data impact the quantitative literacy skills of 11th grade honors level history students at SHS? and 2) What are student's perceptions about the effectiveness of incorporating situated data sets into graphic organizers in order to increase their quantitative literacy skills?

I utilized a convergent parallel mixed method research design (Creswell & Creswell, 2017). Data were collected from 14 participants who engaged in an intervention which taught QL skills by using spreadsheets, graphic organizers, and meaningful data to encourage higher-order cognitive functioning.

Quantitative data were collected through a demographic survey, a pretest-posttest and Likert type questions in post-lesson exit slips. The exit slips were also used to collect qualitative data after each lesson, and a focus group interview augmented the qualitative data collection. During the intervention, qualitative data were also collected through daily observations and field notes.

Although students scored higher on the posttest than the pretest, a paired sample t-test of the difference in scores did not indicate a statistically significant difference. Analysis of the Likert scale and Likert type data indicated that the students did in fact learn new ideas and concepts during the intervention. Qualitative analysis of the exit slip comments, and the focus group interview also suggested that student's learning was increased during the intervention, and they learned significant lessons about charts and graphs and the benefit of using multiple tools while learning.

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CHAPTER 1

INTRODUCTION

It is clear through anecdotal evidence, discussions at educational meetings and information provided in studies, journals, newspapers, books, and magazines that US students are struggling in their studies. Among the areas of struggle is quantitative literacy, or using mathematical skills, to solve problems and understand numeric data in their daily lives. High school students are leaving classrooms with insufficient technology skills (Carnevale, Smith, & Strohl, 2010), and with limited skills in quantitative literacy, the ability to apply mathematical concepts to succeed in their lives beyond high school (Steen, 2000, 2001).

Part of the problem stems from the fact that quantitative literacy standards, although different from traditional mathematic standards, are not clearly differentiated in their own standards throughout the curriculum. "Numeracy is increasingly seen as an integral part of mathematics education, but the precise nature and implications of teaching for numeracy in primary/elementary and secondary schools are still being worked through by the academic, practitioner and policy communities" (Askew, 2015, p. 707). Quantitative literacy (QL) goals are included in many of the 21st Century curriculum standards (Crowe, 2010), but are not uniform across various states and local districts.

In fact, a precise definition is not agreed upon by the various organizations that promote quantitative literacy (Steen, 2000, 2001). Lai and Viering (2012) noted:

> Although these skills are not new, it was not until very recently that educators and policymakers agreed that they should be explicitly included in academic content standards, directly taught alongside the regular academic curriculum, and routinely assessed for all students (p. 3).

There is a societal need for a numerically literate people in today's information age. Children, adolescents, and adults alike need to be able to think critically about the mathematical and numerical information that surrounds us in the media, on the Internet, in schools and workplaces, and in society at large (Gittens, 2015, p.1).

Educational reform has been pushed from the top down (Common Core, 2010; NCLB, 2000; PARCC, 2010), and teachers to a large extent have been unable or reluctant to incorporate appropriate technology skills, including quantitative literacy, also referred to as mathematical literacy or numeracy, into the "student-centered" classrooms that educational leaders have envisioned (Cuban, Kirkpatrick, & Peck, 2001; Liu & Szabo, 2009; Voet & DeWever, 2017).

Students have been labeled "digital natives" (Prensky, 2001, 2009), or "digital residents" (Henderson, Selwyn, & Aston, 2017; Wright, White, Hirst, & Cann, 2014) and according to some have superior technology skills than some of their teachers. Older educational leaders often referred to as "digital immigrants" (Chaves, Filho, & Melo, 2016; Prensky, 2001) have sought to identify and implement new pedagogies to transform classrooms from teacher-centered to student-centered environments (Mishra &

Koehler, 2006; Puentedura, 2010). One goal is to prepare highly numerate students, who have "a functional knowledge of mathematical content; an ability to reason mathematically; a recognition of the societal impact and utility of mathematics; an understanding of the nature and historical development of mathematics; a positive disposition toward mathematics" (Wilkins, 2000, p. 406), and who are skilled at analyzing, inferring and interpreting quantifiable data and making decisions using quantitative or probabilistic information (Steen, 2000). These quantitative literacy skills can be learned across all the disciplines a high school student participates in (Askew, 2015; Bennison, 2015; Wilkins, 2000).

As Wiest, Higgins, and Hart (2007) suggest, quantitative literacy, is not to be considered synonymous or subsumed by the discipline of mathematics (Steen, 2001). Instead, quantitative literacy involves a recognition and understanding of how quantitative information is gathered, manipulated by counting and measuring, represented visually in graphs, charts, tables, and diagrams and ultimately, dependent on context. Steen (2001) likens quantitative literacy to a habit of mind and problem solving that employs both statistics and patterns. Quantitative literacy encompasses mathematical problem solving and decision making that goes beyond practical or daily-life pure-math applications to include civic, professional, leisure and cultural problems and decisions of varying novelty and complexity (Steen, 1990, 1999; Gittens & Facione 2014).

How students learn quantitative literacy is important. The world is increasingly reliant on technology to help understand data, and some technology lends itself to the teaching of quantitative literacy (Kennedy, 2001). Spreadsheets specifically are tools used for the analysis, manipulation, and interpretation of data. Although spreadsheets are

among the oldest forms of computer teaching technology available, many teachers are unfamiliar with the specific ways to use spreadsheets as an effective learning tool. Jonassen (1990, 1996) refers to spreadsheets as “MindTools”, and suggests they offer ways to teach critical thinking, including quantitative literacy skills. The affordances offered by spreadsheets are invaluable to the teaching of QL because students can enter and manipulate data, graph their responses, and use the predictive capability of the spreadsheet for planning purposes. Pea (1985) states that spreadsheets and other mindtools extend cognitive functioning during learning and engage learners in cognitive operations while constructing knowledge that they could not have done on their own. Using the spreadsheet as an instructional device allows students to create knowledge, rather than simply receive instructions or presentations (Jonassen, 1996).

To further enhance learning about quantitative literacy, advance organizers, or graphic organizers, provide useful cognitive skills to aid in comprehension and understanding. Graphic organizers allow learners to focus on the main information in the text and the way it is organized (Colliot & Jamet, 2018). “Adding a graphic organizer to a pedagogical document facilitates not only the selection process, insofar as only key items of information are featured, but also the organization process, as the structure of the text and the hierarchical links between the concepts are made explicit” (McCrudden & Rapp, 2015, p.14).

This chapter includes discussions of the following topics: a) national context, b) local context, c) statement of the problem, including the purpose statement and research questions, d) statement of research subjectivities and positionality and, e) definition of key terms used in the study.

National Context

Despite the research in education and the suggestions for moving towards the student-centered classroom, evidence still exists that the changes are not improving student performance significantly (Keengwe, Onchwari, & Wachira, 2008; Wade, Rasmussen & Fox-Turnbull, 2013). In 2015, American students ranked 25th in Science, 24th in Reading and 39th in Math globally on the Programme for International Student Assessment (PISA), given every three years by the Organization for Economic Cooperation and Development (OECD) in 39 countries (Gurria, 2016, p. 5). Only 27% of the 6,000,000 students who took the ACT in 2017 were college-ready in all four subject areas: Reading, Writing, Math, and Science (ACT, 2017). The National Assessment of Education Progress reported that only 37% of U.S. high school students were college-ready in Math and Science (NAEP, 2015), a decline from the previous report.

In 2016, Brint and Clotfelter declared that "declines in academic preparation were a major part of the explanation for declining graduation rates in community colleges" (p. 18). Even with the advances in educational technology, student preparedness continues to fall behind (Buzzetto-Hollywood, Elobaid, & Elobeid, 2018). In addition, academicians disagree on the necessary skills for college readiness and student success. For instance, Conley and McGaugy (2012) stated that the "ability to formulate problems, find college information, interpret and analyze findings, and communicating in a variety of modes" (p. 31) were the most important skills for college success, while other research produced dissimilar lists (NEA, 2017; Rotherham & Willingham, 2009).

With the introduction of the commercial internet in 1992, educational technology changes were significant: lectures and books gave way to analog instructional devices which eventually prepared the way for digital technology (Januszewski & Molenda, 2008). A new generation of students emerged, referred to as digital natives (Jones, 2010; Prensky, 2001; Thompson, 2013). Experienced teachers, sometimes referred to as digital immigrants, struggled to adjust in the classroom and a gap developed between the digital immigrants and the digital natives (Chaves, Filho, & Melo, 2016; Guo, Dobson, & Petrina, 2008).

As late as 2007, 15% of US teacher education programs did not offer an educational technology course (Kleiner, Thomas, & Lewis, 2007), effectively adding to the difficulty it will take to close the gap. Recent research, however, has suggested that the digital natives may not be as highly equipped in the appropriate technologies as educators were led to believe. Most undergraduate students have grown up using technology primarily for entertainment and social media (Jones & Madden, 2008). "However, undergraduate students' performance on technology competency tests indicates that they generally lack the related skills necessary for academic purposes" (Vickrey, Golick & Stains, 2018, p. 66).

QL is a growing issue among educators in the United States (Askew, 2015; Gittens, 2015; Hillyard, 2012). For purposes of this research, the definition of QL is taken from the American Association of Colleges & Universities (2009) QL VALUE Rubric:

> a habit of mind, competency, and comfort in working with numerical data. Individuals with strong QL skills possess the ability to reason and solve

> quantitative problems from a wide array of authentic contexts and everyday life situations. They understand and can create sophisticated arguments supported by quantitative evidence and they can clearly communicate those arguments in a variety of formats (using words, tables, graphs, mathematical equations, etc., as appropriate) (AAC&U, 2009, p. 1).

Although quantitative literacy has been a much-discussed topic by educators since the 19th century (Cohen, 1982), it was not until the 1950s that the topic first appeared as an educational requirement (Crowther, 1959). At the time, the term numeracy was used as the counterpart to the word literacy (Crowther, 1959; Geiger, Goos, & Forgasz, 2015b), the mathematical yin to reading's yang.

The concept was introduced into the United States under the name quantitative literacy (QL) by Steen (1996, 1997). Since Steen's introduction to the topic, thousands of articles have been written about QL (Grawe, 2015; Vacher, 2014), and national organizations supporting the teaching of quantitative literacy have emerged, including the National Council of the Teachers of Mathematics (NCTM) in 1991 and the National Numeracy Network in 2011. The ASA-NCTM Quantitative Literacy Project in 1991 stated that "it is vitally important that the students of today be taught data analysis skills before they become the workers and leaders of tomorrow" (p. 45). The Association of American Colleges and Universities (2014) has constructed a Quantitative Literacy VALUE Rubric for helping educators teach numeracy in innovative ways to their students at all levels (Vacher, 2014).

Quantitative literacy as a construct is generally taught across the curriculum, most often by non-mathematics teachers (Bennison, 2015; Ginsburg, Manly, & Schmitt, 2006;

Lucas, 2019). QL is often taught by teachers in Social Studies, Science, and English with the idea to connect QL with real-world context and interpretation (Geiger, Goos, & Forgasz, 2012, 2015; Jacobs & Castek, 2018). Often, however, non-math teachers are unable to find adequate quantitative literacy lessons, or examples, for their students (Ferme, 2014; Swan & Swain, 2010), while others feel inadequate for the task (Bennison, 2015; Crowe, 2010).

Educational professionals are broadly aware of QL because the skills are covered vaguely in the standards, without specific regard as to who is to teach them (Ferme, 2014). There are many opportunities in non-math classes to teach quantitative literacy, but many teachers regard them as difficult or detracting from other curricular work. In fact, asking a non-math teacher to address quantitative literacy is seen negatively, in that the task is an additional requirement to fit into the already full schedule (Ferme, 2014).

A teacher's confidence in teaching quantitative literacy appears to be correlated to their individual achievement and knowledge of the scope of QL beyond arithmetic (Beswick, 2008). Quantitative literacy is often taught outside of math because individual teachers feel the skills are important for student success (Bennison, 2015; Ferme, 2014). Opportunities abound in history and economics to use the study of QL to help students make better decisions (Callingham, Beswick, & Ferme, 2015; Crowe, 2010). "If all teachers are able to identify and exploit the quantitative literacy learning opportunities that exist in the subjects they teach, then student's QL capabilities along with learning in each subject is likely to be enhanced" (Bennison, 2015, p. 561).

Local Context

The primary goal of the SHS School District is to "Support student growth and academic achievement through a focus on the continuous review and refinement of curricula, instructional practices, and professional development" (SHS District Goals, 2017, p. 1), by studying and incorporating 21st Century Skills of collaboration, creativity, communication, and critical thinking throughout all grade levels and content areas (BOE Policy 2200, 2016).

As another means to accomplish this goal, the District started a one-to-one Chromebook initiative in grades 8-12, beginning in the fall of 2018 (WRSD 1:1 Portal, 2018). Each student is assigned a Dell Chromebook and charger, which is equipped with Google Classroom, used for sharing academic information and assignments, but not for grading and administration. Because the area is densely populated, wi-fi coverage is available to all but a few students, who have easy access to libraries and establishments with free wireless internet connections. The district provides a few wireless hotspots to students who are unable to access it at their homes. All students are required to bring their Chromebook with them to every class and may use them off-campus and at home for District approved activities.

Professional development to support the initiative includes a program to encourage all teachers to pursue Google certification as part of the District's Professional Development Plan (BOE Policy 3240, 2017). Aside from the Google training, no mandatory, long-term, formal curriculum framework has been established for creating student-centered lessons or incorporating technology-driven lessons into the individual or department curriculum units. Because there is no district-wide mandate, teachers are free

to develop their own technology-infused lessons, which reduces the chance for new technologies to be uniformly integrated into the student's technical competencies but does offer students access to a wider variety of technology applications.

Suburban High School has approximately 805 students in Grades 9-12, with a Chromebook assigned to each student, backup Chromebook carts, five computer labs, the technical support staff and a media center administrator all providing desktops, laptops, Chromebooks, and support for student daily use. We have a typical high school faculty: teacher experience ranging from one year to over 30 years, technology proficiency varying from novice to highly competent and education levels from bachelor's degree to Doctorate. We do not have a common set of technology objectives that should be taught/learned in the classroom except for the 2014 NJ State Learning Standards in Technology (NJDOE, 2014), the 2014 NJ State Learning Standards in 21st Century Standards in Life and Career Skills (NJDOE, 2014) and the CCSS Math Standards (NCTM, 2020). In 2016, we received an overall self-reported score of 6.0/10.0 on the Future Ready Framework, with a 5.8/10.0 on Curriculum, Assessment and Instruction. (Suburban School District Digital Learning Readiness Report (2016).

For the 2020-21 school year, the Suburban Regional High School has approximately 805 students, of which 51% are female and 49% are male. I teach approximately sixty-six 11th and 12th graders this year, 77% of whom are white, 11% Asian, five% Black and five % Hispanic. All of them are expected to go on to college.

This year because of the COVID-19 crisis, 168 of the students at SHS have chosen to attend classes remotely, which is approximately 21% of the total student population. The District has adopted a hybrid teaching schedule, where the 625 students

who have chosen to attend classes physically are divided into two groups which meet in the building on some days and from home on others. The on-site students are divided among Group 1 and Group 2 alphabetically, with the remote students attending class online with their respective groups. In my five classes, 17 of the 66 students, or 26% of the class enrollment, have selected remote only instruction, which is slightly higher than the school's overall percentage.

The District is ranked among the upper third of NJ school districts according to the NJ Department of Education (NJDOE) District Factor Grouping (DFG) (NJDOE, 2018) based primarily on socioeconomic status. My students generally do not lack resources with which to be successful in school. Regardless of their status, however, my problem of practice is based on my belief that they are not ready for the rigors of a college academic setting because they have not learned essential analytical skills for success.

As of this writing, the district has made a concerted effort to integrate Google products heavily into the classrooms at all grade levels. For the past two years, cohorts of teachers have been attending professional development (PD) classes with the intention of achieving Google Educator certification. The PD classes primarily provide information about Google products to aid in the completion of the certification process and introduce many of the newer Google products. In lieu of a Learning Management System (LMS), the district uses Google Classroom as the primary platform for the delivery of instruction and collection of student work. The use of the Google basic applications – Docs, Sheets, Slides, Sites and Forms – are left to the teacher's familiarity and knowledge of the application. There are several Certified Google Instructors in the district who can and do

provide informal support to their colleagues. Google Sheets was used as a Mindtool (Jonassen 1990) because all students have consistent access to it using their assigned Chromebooks. The purpose of this research project is to combine the use of the spreadsheet (Google Sheets) with graphic organizers to redevelop selected unit and lesson plans to maximize the learning experiences of my students regarding their quantitative literacy skills. The effectiveness of the intervention was measured by analyzing student feedback and performance on pre and posttest assessments, then revising the lessons for the next year thereby improving learning retention.

Statement of the Problem

Despite integrating technology daily into my classroom lessons, former students routinely report back that they are not prepared for the technology practices and quantitative literacy skills that will make them successful in college, work, and life. I also have experienced firsthand that many of my higher-level students do not have enough QL skills to adequately interpret charts and graphs that are necessary for them to be successful in classroom activities, summative assessments, and/or standardized tests. Being college ready is a process that takes time and begins before a student's senior year in high school (ACT Policy Report, 2005; Gittens, 2015). Either the skills necessary to interpret numbers and charts have not been adequately explained to them during their previous classroom experiences, or they have not been given appropriate practice at analyzing charts and data (Dehaene, 1997; Steen, 2001). In addition, more numerate individuals may be more adept at complex decision making including those involved in financial decisions (Peters, Västfjäll, Slovic, Mertz, Mazzocco, & Dickert; 2006).

Purpose Statement

The purpose of this action research is to evaluate the effectiveness of graphic organizers, using student relevant data, and spreadsheets as a mindtool, on the quantitative literacy skills of 11th grade students enrolled in an Honors Level United States history course enrolled at SHS.

Research Questions

1. How does the implementation of the use of advanced graphic organizers and the use of a spreadsheet to manipulate authentic data impact the quantitative literacy skills of 11th grade honors level history students at SHS?
2. What are the students' perceptions about the effectiveness of incorporating authentic data sets into graphic organizers in order to increase their quantitative literacy skills?

Statement of Research Subjectivities and Positionality

I was born in rural South Carolina, in an area and time that was still struggling with basic civil rights. My mother, responding to the poor education system in SC at the time, insisted early on that we would not depend on the schools for our education. I could read the entire daily newspaper by the time I was four, and by age five, an entire encyclopedia set [no TV to compete with in those days]. I naturally assumed that other students did the same and became quite frustrated by a perceived lack of effort from both students and teachers through grade 12. We were lower middle class, and I gratefully accepted an opportunity to go to West Point, where I encountered for the first time, other students who shared my academic zeal. Our classes were rigorous and exacting. I left with the new idea that discipline and desire are a potent combination for learning. The

only teaching style I had encountered in 16 years of school was direct instruction, most often without benefit of modern technology. I assumed that everyone else could learn the same way and expected them to. My wife, a social worker, and I raised our children to value learning.

In 2003, I became an Alternate Route Teacher with no formal knowledge of educational pedagogy, but extensive knowledge in the content areas of history and economics. Much the same as I had learned, I taught: primarily lectured, used PowerPoint and provided graphic organizers as my primary instructional method, which relates to my curricular belief of "connecting to the canon", or transmitting knowledge to be received and carried onward by students (Joseph, Bravmann, Windschitl, Green, & Mikel, 2000). As a result, I am aligned closely with the pragmatic worldview, which arises from "actions, situations and consequences" (Creswell & Creswell, 2017, p. 10) and focuses on all approaches available to understand the problem (Rossman & Wilson, 1985), using either quantitative or qualitative means to arrive at the conclusion. As a self-learner, I am always aware that there are multiple perspectives and multiple approaches to solving problems.

I understand that innate, or inherent, subjectivity issues are undeniably present in my research (Roulston & Shelton, 2015). In my classes, I expect top performance on every activity and for students to learn the material presented to them. I expect students to show improvement by reflecting on my comments and integrating the new knowledge they have learned. I also know that because of my size, age and experience I gain respect, and a little fear, from them that other teachers do not get. Subjectivity, according to Peshkin, has the capacity to "filter, skew, shape, block, transform, construe and

misconstrue what transpires from the outset of a research project to its culmination" (1987, p. 17). I must always be aware of this bias, in order to hear my student's comments, feedback, and perceptions (Berg, 2007).

In my role as a teacher, I have power in my title, extensive content knowledge, ability to assign grades, and physical presence. But students also have power - the power to ensure that my best efforts fall short by not participating. Because of our close daily contact and student-teacher relationship, I am an insider, but at the same time, I am an outsider to their peer groups and social networks. According to Herr and Anderson (2005), I am an insider in terms of research because I am engaged in self-study and reflection on my own practice as well as student perceptions of the changes. I must be careful to not imply to my students that my research is important to me and that it should also be important to them (Drew, Hardman & Hosp, 2007).

It is based on my own reflexivity, however, that I am engaged in this research. I believe we have an extraordinary capacity to store information but are not effective at retrieval (Davidson, 2011). However, the digital world has overtaken us, and searching seems to have replaced memorizing (Sheninger, 2014). Technology has changed learning and to be more effective as a teacher I must transform my own practice to allow students to learn in a student-centered way. To do that, I must believe that the pedagogical changes I make are beneficial to them and increase their learning and must trust that their perceptions have helped to recraft my effectiveness as a teacher.

Definition of Terms

Action research. Defined as "any systematic inquiry conducted by teachers, administrators, counselors or others with a vested interest in the teaching or learning

process or environment for the purpose of gathering information about how their schools operate, how they teach and how their students learn (Mills, 2011)" (Mertler, 2016, p.4).

Authentic data. Authentic data is information that is closely related to the current situation that students are in, meaning that the data used for illustration and understanding is closely linked to the current subject being discussed, and important to the student's personal futures (Curry & Cherner, 2016; Lee & Branch, 2017). In lieu of generic data to teach spreadsheets and charts, the intervention employed data about the effects of education and earning potential, technology selection and usage, election results and current information displayed in the news and online (Howard, Ma & Yang, 2016; Koh, Chai & Tsai, 2014).

Constructivism. Constructivism is a theory that equates learning with creating meaning from experience (Bednar, Cunningham, Duffy & Perry, 1991). Most cognitive psychologists think of the mind as a reference tool to the real world; constructivists believe that the mind filters input from the world to produce its own unique reality (Ertmer & Newby, 2013; Jonassen, 1991a). In constructivism, "Humans *create* meaning as opposed to *acquiring* It" (Ertmer & Newby, 2013, p. 55). Likewise, it is essential that content knowledge be embedded in the situation in which it is used. (Ertmer & Newby, 2013). Brown, Collins, and Duguid (1989) suggest that situations assist in construction of knowledge (along with cognition) through student activities.

Digital fluency. The ability to leverage technology to create new knowledge from critical thinking, complex problem solving and social intelligence, or to create something new with digital tools (Sparrow, 2018). Digital fluency also draws from the following specific fluencies: Communication fluency, or the ability to choose an

appropriate medium for a specific task, and data fluency which is the ability to make informed decisions (Sparrow, 2018).

Digital immigrant. In the original definition by Prensky (2001), digital immigrants were people born before 1980 who did not grow up immersed in digital technology. Since Prensky's original definition, others have refined the term to mean that digital immigrants are those who have adapted to the technology-rich environment through their ability to learn and adjust to new technologies (Berman & Hassell, 2018). Ransdell, Kent, Gaillard-Kenney and Long (2011) concluded that digital immigrants were less confident in the use of technology than digital natives, but they can apply what they learned about technology better than the natives.

Digital literacy. Communication through technology in which **"**learners take ownership of their work by generating digital artifacts and find ways to create evidence of work, showcase their experiences, craft their own narrative, and participate in the collective web" (Becker, Pasquini & Zentner, 2017, p. 7).

Digital native. Those born after 1980 who have been immersed in digital technology their whole lives (Prensky, 2001) and have "the ability to cognitively process multiple sources of information simultaneously (multi-taskers)" (Kirschner & DeBruyckere, 2017). Prensky also stated that digital natives thrived on instant gratification, frequent rewards, and multitasking.

Digital resident. Digital residents have been described as "accustomed to experiencing digital technologies as seamless, 'always-on' and highly participatory social spaces (Wright et al. 2014). For these students, digital environments such as the internet

are a way of life rather than discrete functional tools that can be turned on and turned off" (Henderson, Selwyn & Aston, 2017, p. 1568).

Graphic organizers. Graphic organizers can be regarded as organizational signals, emphasizing key items of information and their interrelations, and graphic organizers allow learners to focus on the main information in the text and the way it is organized. (Colliot & Jamet, 2018). Semantic visual displays can promote cognitive processes in several ways (McCrudden & Rapp, 2015). Adding a graphic organizer to a pedagogical document, such as a spreadsheet activity, facilitates not only the selection process, insofar as only key items of information are featured, but also the organization process, as the structure of the text and the hierarchical links between the concepts are made explicit.

Mindtools. Mindtools are computer applications that, when used by learners to represent what they know, necessarily engage them in critical thinking about the content they are studying (Jonassen, 1996). "Spreadsheets are flexible Mindtools for representing, reflecting on, and calculating quantitative information. Building spreadsheets requires abstract reasoning by the user, they are rule-using tools that require that users become rule-makers. Spreadsheets also support problem-solving activities, such decision analysis reasoning requires learners to consider implications of conditions or options, which requires entails higher order reasoning" (Jonassen, 198, p. 4).

Numeracy. The term numeracy is included here to recognize that it is a more widely used term outside the United States, and references to numeracy in this document also refer to quantitative literacy. Numeracy is a term that is often used interchangeably with "quantitative literacy" or "quantitative reasoning". The choice of terms is based on

history, culture, and region (Geiger, Goos & Forgasz, 2015). In the US, the term "quantitative literacy" was made popular by Steen in 1996, 1997 and 2001, and is used in international and national organizations, such as the Organization for Economic Cooperation and Development (OECD), the National Numeracy Network (NNN) and the Programme for International Student Assessment (PISA). That distinction suggests that articles on numeracy and quantitative literacy reflect the cultures and priorities in different parts of the world. "Numeracy is the ability or tendency to reason critically about quantitative information. Numeracy skills are used when applying one's knowledge of numbers, arithmetic, statistics, measures, and mathematical techniques to situations that require the interpretation and evaluation of quantitative information" (Gittens, 2015, p. 3). Also, "numeracy relates to the knowledge, skills, and dispositions or habits of mind related to understanding and using certain aspects of statistics" (Crowe, 2010, p. 106). Numeracy also connotes a familiarity and confidence with notions of change, chance, quantity, shape, and dimension, creating real-world relevance and connections—both cross-discipline and within mathematics. (Steinberg, Johnson & Pennington, 2014). The Adult Literacy and Lifestyle (ALL) Skills Survey defines numeracy as "the knowledge and skills required to manage mathematical demands of diverse situations" (Goldsteyn, Vermeulen & deWolf, 2016, p. 370).

Quantitative literacy. Also known as numeracy or Quantitative Reasoning, QL is a "habit of mind," competency, and comfort in working with numerical data. Individuals with strong QL skills possess the ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations. They understand and can create sophisticated arguments supported by quantitative evidence

and they can clearly communicate those arguments in a variety of formats (using words, tables, graphs, mathematical equations, etc., as appropriate)" (AAC&U, 2019, p. 1). This is the working definition for quantitative literacy in this action research.

Situated cognition. The major pioneering work in the area of situated cognition has focused on the relationship between mathematics learning in school and mathematics 'in context', namely in the workplace and in domestic life (Harris, 1991), or in other words, the concept of numeracy. In situated cognition, learning can be facilitated through a series of processes such as modeling, coaching, scaffolding, fading, articulation and encouraging learners to reflect on their own problem-solving strategies (Collins, Brown and Newman, 1989; Vygotsky, 1978). In the classroom we should seek to we should seek to "ground theories of action in empirical evidence, generalizing from records of particular, naturally occurring activities" (Hennessey, 1993, p 4). This strategy is also referred to as providing authentic, or meaningful, context to lessons (Brown, Collins & Duguid, 1989).

CHAPTER 2

LITERATURE REVIEW

The purpose of this action research is to evaluate the effectiveness of graphic organizers, using student-relevant data, and spreadsheets as a mindtool, on the quantitative literacy skills of 11th grade students enrolled in a US History II Honors course enrolled at SHS. The study aims to resolve the purpose statement by answering the following two research questions: 1) How does the implementation of the use of advanced graphic organizers and the use of a spreadsheet to manipulate authentic data impact the quantitative literacy skills of 11th grade US History II Honors students at SHS? and 2) What are the students' perceptions about the effectiveness of incorporating authentic data sets into graphic organizers in order to increase their quantitative literacy skills?

The literature review process began as a casual inquiry into the reasons that students were not prepared for many of the technology requirements for college and career, including the ability to read and interpret charts and graphs correctly. During that search, I read an article, "Computers as Mindtools for Engaging Critical Thinking and Representing Knowledge", (Jonassen, 1998), which led me to three books that started my search for better way to help my students learn quantitative literacy (QL) skills. The first was "Computers as Mindtools for Schools: Engaging Critical Thinking", 2nd Edition

(Jonassen, 1996), and the second, “Meaningful Learning with Technology”, (Howland, Jonassen, & Marra, 2012).

I used Google Scholar as the initial search engine looking for the key phrases *Mindtools, technology, numeracy, Quantitative Literacy, authentic data, graphic organizers,* and *student-centered learning*. I established Google Scholar alerts which returned from 6-10 new articles weekly about the phrases. Mendeley, a citation and reference management tool, offered a similar search tool which was used to look for the same search parameters. As articles were added to my annotated bibliography, references from the completed articles were used to add to my understanding of the topic. Various academic search engines, available through the University of South Carolina library, were used, primarily Academic Search Complete (EBSCO Host) and JSTOR.

Google Scholar was often consulted first to make the library database searches more efficient. I later began to research for the uses of graphic, or advanced, organizers as learning tools. The primary search terms used in the databases were: *numeracy, quantitative literacy, graphic organizers, advanced organizers, social studies, student-centered learning, student perception of learning, student perception of numeracy, student perception of ICT, supporting teacher's numeracy, 21st century skills, 21st century learning, professional development, validity, numeracy surveys, mathematical literacy, college readiness, and career readiness*. Finally, several articles from this literature review were drawn from *TechTrends* and *the* AECT bi-monthly publication *Educational Technology Research & Development.*

This literature review is divided into five main sections: (a) theoretical background for the study, (b) the primary definitions of quantitative literacy, (c) use of

mediated technology such as spreadsheets (mindtools) to increase quantitative literacy, (d) the impact of graphic organizers in social studies, including economics and history classes and e) student perceptions of the attempt to use mediated technology and graphic organizers as learning platforms. The first section discusses the constructivist underpinning of the concept of student-centered learning, a key tenet in quantitative literacy instruction. The second section examines the primary definitions of quantitative literacy and the various educational and social programs that are furthered by QL. administrators in the support of the effort are discussed. The third section researches the use of spreadsheets as an effective teaching and learning tool, and the fourth section reviews the specific use of organizers and spreadsheets to teach quantitative literacy in social studies and acknowledges the lack of literature on this area of research.

Theoretical Background

Underlying the preparation for choosing a topic for action research is the selection of the theoretical framework which underpins the premise of the study. This section describes the constructivist background in general, and its connection to student-centered learning. After discussing constructivism in general terms, the review discussed the constructivist background incorporated into QL instruction, then the use of situated cognition in the teaching and learning of quantitative literacy.

The theory of constructivism is at the heart of this study - “Humans *create* meaning as opposed to *acquiring* it” (Ertmer & Newby, 2013). Constructivism suggests that knowledge is not passively received but actively built up by the cognizing subject and the function of cognition is adaptive and serves to organize the experiential world (Bednar, Cunningham, Duffy, & Perry, 1991; Lerman, 1989; Von Glaserfeld, 1995).

Constructivism places students at the center of learning, which promotes active learning that in turn improves retention (Lumpkin, Achen, & Dodd, 2015; Yazedjian & Kolkhorst, 2007). Teachers with traditional (behavioral teaching) beliefs will implement lower-level technology instruction, while teachers with constructive pedagogies will deliver student-centered technology lessons (Ertmer& Ottenbreit-Leftwich, 2010; Judson, 2006).

Teachers who adopt a constructivist teaching approach to one-on-one programs “use more student-centered teaching methods and have more personal interactions with students" (Jin & Schmidt-Crawford, 2017, p. 75) and tend to use technology more for student-centered outcomes (Arancibia-Herrera, Garganté, Caro, & Sigerson, 2018; Hermans, Tondeur, Van Braak, & Valcke, 2008). Student-centered learning, one of the outcomes of constructivism, means students are active constructors of meaning, knowledge is constructed in authentic contexts and teachers guide and support student learning (Baetan, Dochy, & Struyven, 2013).

When Koehler and Mishra introduced the Technological Pedagogical Content Knowledge (TPCK) framework in 2005 they argued for the “role of authentic design-based activities in the development of this knowledge” (p. 131). They presented the framework through a *Learning by Design* emphasis which is “a constructivist approach that sees knowing as being situated in action and co-determined by individual environment interactions” (Koehler & Mishra, 2005, p.134). Their approach emphasized the value of authentic and engaging ill-structured problems that reflect the complexity of the real world (Brown, Collins, & Duguid, 1989; Marx, Blumenfeld, Krajcik, & Soloway, 1997). In fact, the main role of the instructor in this framework is that of a facilitator and problem-solver rather than just an expert in the content. Learning in this context involves

becoming a practitioner, not just learning about practice (Brown & Duguid, 1991). One caveat to the application of constructivism here is that teachers then must understand that their decision about implementing TPACK alters the ability of the students to construct their own experiences (Olofson, Swallow, & Neuman, 2015).

Quantitative literacy instruction is also situated in constructivism. Quantitative literacy need not be taught as a specific skill but used to enhance other subject material, such as economics or social studies (Ferme, 2014). Swan and Swain (2010) regarded the following five elements of QL instruction to be the most important: classifying mathematical objects, integrating multiple representations, evaluating mathematical statements, creating, and solving problems, and analyzing reasons and solutions. These approaches clearly engage the student in the creation of new knowledge, an overarching principle of constructivism (Ertmer & Newby, 1993; Yilmaz, 2011).

Need for Student-Centered Learning in Quantitative Literacy

In a 1999 article, Steen wrote that "numeracy, not calculus, is the key to understanding our data-drenched society" (p. 9). Earlier in the article, he claimed that many national surveys had concluded that students leave high school with well below minimum standards for "quantities literacy" (p. 8). The problem has been exacerbated with both the volume of data and the speed at which it is presently accessed (Revilla, Ferreira, & Augusti, 2019). 21st century standards makers are calling for an increased emphasis on quantitative literacy across the curriculum (Darling-Hammond & Richardson, 2009; Kay, 2010). Not only does QL education needs to be emphasized, but teachers should also be trained, and non-math teachers should learn, or be taught to look for, opportunities to teach quantitative literacy (Ferme, 2014; Swan & Swain, 2010).

Quantitative literacy is part of the 21st century skills standards that students need to learn to be successful in college and career activities. Students are not learning the necessary skills for that success according to (ACT, 2014; Conley, 2010; NAEP, 2013; USDOE, 2013a; Venezia & Jaeger, 2013). Quantitative literacy skills are also limited in adults as well as reported by major assessment agencies (OECD, 2013a; Saal, Gholson, Machtmes, K. & Machtmes, R., 2018).

Part of the reason that students are not prepared for the challenges that lay ahead is that teachers often do not teach technology-based skills effectively, nor do they recognize opportunities to present quantitative literacy skills in non-mathematics classes (Collie & Martin, 2017; Ertmer & Ottenbreit-Leftwich, 2010; Fusco, 2012; Margolin, Pan, & Yang, 2019; Mishra & Koehler, 2006). Non-math teacher's ability to teach QL is sometimes limited by their personal experience, and by their inability to find room for it in their curriculum (Ferme, 2014; Goldsteyn, Vermeulen, & deWolf, 2016; Zimmerman, 2015).

Definitions of Quantitative Literacy Terms

Numerate US citizens were mentioned by de Tocqueville as early as 1830 when he described Americans as weighing risks, calculating advantages, and gauging utility (Cohen, 1982). There are three primary terms, or definitions, of quantitative literacy, all shaped by different academic, cultural, social, and temporal influences (Ginsburg, Manly, & Schmitt, 2006). The oldest modern definition of quantitative literacy, almost always referred to as numeracy in early writing, comes from England in 1959 (Crowther) which is commonly used by current and former members of the UK. The term was modified in England in 1982 by Cockcroft who added a mathematical component to numeracy. In

the US, the term “quantitative literacy” proffered by Steen (2001, p. 1) contained seven dimensions, including reasoning with data and logical thinking. Two major international educational organizations, the Programme for the International Student Assessment (PISA) and the Programme for the International Assessment of Adult Competencies (PIACC) have different, and evolving, definitions for “numeracy” (Madison & Steen, 2008). Other variations of the term “numeracy” appear in the educational literature from Africa and South America (Geiger, Gooz, & Forgasz, 2015).

Definitions

The definition for quantitative literacy used for this action research project is the definition for Quantitative Literacy offered by the Association of American Colleges and Universities (AAC&U) in 2009. The definition is listed prominently at the top of the first page of the Quantitative Literacy VALUE Rubric and defines QL as:

> a habit of mind, competency, and comfort in working with numerical data. Individuals with strong QL skills possess the ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations. They understand and can create sophisticated arguments supported by quantitative evidence and they can clearly communicate those arguments in a variety of formats (using words, tables, graphs, mathematical equations, etc., as appropriate). (AAC&U, 2009, p. 1)

Other common definitions of quantitative literacy as they appear in the scholarly literature are listed below.

Numeracy. The earliest known definition of numeracy was given by the British Ministry of Education (Crowther, 1959) – “a word to represent the mirror image of

literacy … an understanding of the scientific approach to the study of phenomena - observation, hypothesis, experiment, verification and the need in the modern world to think quantitatively" (p. 282). This involved the concept of quantitative thinking and mathematical literacy which advanced the idea that numeracy was the ability to apply classroom math to real-world problems (Geiger et al., 2015). As the term became more mainstream, other scholars added to the definition, accounting for digital literacy and the new 21st Century objectives (Askew, 2015; Callingham, Beswick, and Ferme, 2015; Gittens, 2015).

Mathematical literacy. Used primarily in Europe, this term has been adopted by the OECD and its PISA Assessment organization. The PISA definition has changed with each three-year iteration of the PISA test, first administered in 2000. The first definition was "to understand and engage in mathematics" (OECD, 2012), and changed to "identify and understand the role math plays to an individual's capacity to formulate, employ and interpret mathematics" (Craig, 2018; Jonas, 2018).

Quantitative literacy. This term, introduced by Steen (1996, 1997) in the US in the late 1990s, is the most prominently used in US literature and academic circles concerning numeracy (Bennison, 2015; Callingham et al., 2015). Steen's definition, "Numeracy is concrete and contextual, offering contingent solutions to problems about real situations" (2001, p. 2), includes the ideas of building confidence with math, and the use of math to solve complex problems in other curricular or life areas (Steen, 1997; Steen, 1999; Steen, 2001). In the US, the term quantitative literacy (QL) is much more common than numeracy. Some view quantitative literacy as the more inclusive term, while others prefer the alternative expression *quantitative reasoning*. Robert Orrill (2008)

has described QL as a cultural field where language and quantitative constructs merge and are no longer one or the other. From this perspective, "quantitative literacy" is a more inclusive term than the narrower word "numeracy” (Madison & Steen, 2008).

Numerical literacy. As defined by the National Numeracy Strategy in England, numerical literacy is “a proficiency which involves confidence and competence with numbers and measures. It requires an understanding of the number system, a repertoire of computational skills, and an inclination and ability to solve number problems in a variety of contexts. Numeracy also demands practical understanding of the ways in which information is gathered by counting and measuring, and is presented in graphs, diagrams, charts, and tables” (Brown, Askew, Millet, & Rhodes, 2003, p. 658).

Role and function of quantitative literacy

The role of quantitative literacy for students is increasingly under debate and the arguments range from its usefulness in multiple curricular areas to its relegation back to the mathematics classroom (Crowe, 2010). Quantitative literacy, at its basic level, is applying mathematical concepts to real-world problems. QL may be taught outside of the math classroom, by teachers who incorporate it into their own curriculum (Collie & Martin, 2017). The following areas are essential components of quantitative literacy education.

Digital literacy. Quantitative literacy as part of digital literacy is a theme that has evolved since the 1959 Crowther report, which saw numeracy as the mathematical counterpart to literacy. Others have claimed that the emphasis on digital literacy is the tantamount function of quantitative literacy (Ferme, 2014; Madison & Steen, 2008; Thornton, 2017).

21st Century skills. As 21st century skills have become more important and cross- curricular lines, studies indicate that quantitative literacy can be taught effectively in non-math classrooms, provided teachers are comfortable and can identify good opportunities to teach numeracy in authentic situations (Beriswill et al., 2016; Blau, Peled & Nusan, 2016; Howland, 2013; Kay, 2010; Koehler et al., 2011; Winslow, 2016). In the P-21 Career Ready Standards, CRP8 requires students to be able to "Utilize critical thinking to make sense of problems and persevere in solving them", which is in the domain of quantitative literacy education (NJDOE, 2017).

Participation in society. Students and adults are engaging more frequently with mathematical data that must be analyzed for them to function fully as informed citizens. (Askew, 2015; Geiger, Goos, & Forgasz, 2015; Swan & Swain, 2010). As adults, individuals need quantitative literacy skills to make informed decisions and participate capably in government and work-related activities (Askew, 2015; Curry, 2017).

Participation in social studies. Increasingly social studies teachers can incorporate quantitative literacy lessons for students, as teachers put QL-related topics into their daily lessons. Teaching with charts and graphs, tables of numbers, and spreadsheets with numbers can enrich the social studies content and increase quantitative literacy skills in students (Lake, 2002; Steen & Madison, 2008). However, research has shown that both experienced teachers and new hires are reluctant to incorporate technology skills, albeit for different reasons (Zhao, 2007).

There is limited research on the teaching of quantitative literacy across the curriculum. Many non-math teachers are afraid to introduce the topics into their classes, many feel restrained by the constraints of time and curriculum requirements and others

simply do not understand the concept themselves. (Crowe, 2010; Ferme, 2014; Swan & Swain, 2010; MacDougall, 2010).

Use of Mediated Technology to Enhance Quantitative Literacy

Although there have been several studies about the use of mediated technology in general, most of the research was conducted at universities and either studied college students or high school students at local or affiliated schools. Of all the curricular area studies, social studies research represents less than 3% of all the ICT studies (Pareto & Willermark, 2019). Findings from the early studies of ICT use reported that social studies teachers were the least likely to use technology in the curriculum and to engage students in higher-order thinking (Anderson & Becker, 2001; Ravitz, Becker, & Wong, 2000).

Effectiveness of Technology Mediation in the Social Studies Classroom

Even though there have been few research projects involving social studies there have been a few gauging the effectiveness of ICT in social studies, which have discussed the reason for the effectiveness levels in social studies and the lack of generalization of any conclusions (Arancibia et al., 2018; Byker, 2014; Curry & Cherner, 2016; Gomez, 2015; Van Vaerenewyck, Shinas, & Steckel, 2017).

Current Status of Research in Teaching Quantitative Literacy in Social Studies

Because most social studies teachers are not math teachers there is some hesitation to include numeracy in the curriculum, perhaps because there are few curriculum mandates to do so (Beck & Eno, 2012; Bennison, 2015; Rosenburg & Koehler, 2015; Voet & DeWever, 2017). Where there are references to quantitative literacy, the precision of the requirements is often vague (NJDOE, 2017).

Use of Graphic Organizers in Developing QL Skills

The concept of the graphic organizer began with Ausubel's (1960) research on using advanced organizers in learning difficult material by engaging what students already knew about a topic prior to learning the new material (Merkley & Jeffries, 2001). "Ausubel concluded that when used as a prereading tool, an advance organizer has the potential to link prereading information with a reader's existing schema" (Merkley & Jeffries, 2001, p. 351). Subsequent research expanded the application of structured overviews to include a "hierarchically organized visual display of information" (Merkley & Jeffries, 2007, p. 351) and the term structured overview was replaced with the term graphic organizer by Dunston (1992) and Griffin, Simmons, and Kameenui (1991). Novak and Gowin (1984) emphasized the importance of labeled links between concepts.

Graphic organizers are visual models (Ausubel 1960) that provide teachers and students with tools, concepts, and language to organize, understand, and apply information to achieve a variety of purposes and outcomes (Gallavan & Kottler, 2007). Graphic organizers are often used as scaffolding tools to help students make sense of text or visual images that are difficult to interpret without assistance. Graphic organizers are available in a variety of forms, each with their own specific scaffolding method. Organizers may be standardized or customized by individual teachers and may require students to either fill in blank spaces, reflect on the material under consideration or retell the material in their own way.

Graphic organizers empower students to take responsibility for their own learning, negotiate and personalize meaning, share information with others, and make group presentations (MacKinnon & Deppell 2005). They may be created with a variety

of technology tools, such as presentation software or spreadsheets, generated by hand and displayed in a variety of formats: paper, whiteboard, smartboard, or embedded in an online activity. Various cognitive skills are utilized when using graphing organizers, depending on their intended purpose and level of difficulty. Different cognitive skills are also used depending on whether the student creates or completes the organizer.

Graphic organizers may be used in three ways: to preassess knowledge of a subject, to provide for notetaking and building relationships, and to review, reinforce or assess learning (Vacca & Vacca, 2001). Graphic organizers allow teachers and students to acknowledge what is known, dispel misinformation and misconceptions, brainstorm new possibilities, predict outcomes, process information, share ideas, and see their outcomes in simple and easy-to-recall representations (Keppell,2001). Each of these skills requires different types of organizers, as indicated by Gallavan and Kottler (2007). A list of eight types of graphic organizers, by function, includes organizers that: assume and participate, position and pattern, group and organize, compare and contrast, relate and reason, identify and imagine, estimate and evaluate and combine and create.

Student Perceptions of Technology Mediation Efforts

Parajes (1992) stated that "Beliefs cannot be directly observed or measured, but must be inferred from what people say, intend and do" (p. 314). The idea of measuring student perceptions has been studied, many of which have been about student perception of Information and Communications Technology (ICT) implementations and instruction at the college level. Little study has been done, however, on student perception of ICT and the Student-Centered Learning Environment (SCLE) at the high school level. Among many other teaching design frameworks, Technology Pedagogy and Content

Knowledge (TPACK) (Mishra & Koehler, 2005, 2007, 2009) and the enhancement of student-centered learning have been studied in the past few years, as the framework lends itself to student-centered lessons, if the instructor plans for the proper combination of TPACK in the lessons or units (Kimmons, 2018; Lee & Branch, 2018; Niess, 2011; Tseng, 2018).

Student Perception of Teacher's Efforts to Mediate with Technology

Student's general reactions and feelings about teacher efforts in ICT reveal that students are generally positive about their teachers' efforts to integrate technology if it is done properly (Lumpkin et al., 2015; Shroff, Ting, & Lam, 2019), enlists student support (Wynn, 2013) and increases student engagement (Tillapaugh & Haber-Curran, 2013). Student perception of ICT integration by their teachers is loosely based on what the students believe about the teacher's views on technology integration (Lee & Branch, 2017; Nelson, Voithofer & Cheng, 2019; Shroff, Ting, & Lam, 2019; Wynn, 2013). Student perceptions of teacher practice with TPACK have not been studied as widely as the teacher practice activities with ICT (Delcore & Neufeld, 2017; Tseng, 2018).

CHAPTER 3

METHODS

This methods section explains a) the reasons for choosing this particular action research study, b) the research design and explanation of action research, c) the settings and a description of the study participants, d) a description of the intended intervention, e) description of data collection methods, f) an overview of anticipated data analysis procedures, g) a discussion of the rigor and trustworthiness of the data analysis, and h) plans for sharing and communicating findings.

National organizations, such as the National Association of Secondary School Principals (NAASP) along with other national organizations are pushing for an increase in quantitative literacy (QL) skills, although QL skills have remained in the background of the education sector (NAASP, 2017). The organization believes that without increased QL skills American students will continue to fall behind foreign competitors in 21st Century job skills, particularly those in Science, Technology, Engineering, and Math (STEM), and that keeping those jobs in the US will boost American productivity and economic success (NAASP, 2017). Increased QL skills could also increase wages and decrease American unemployment (Peterson, 2013). This action research project studied potentially effective ways of increasing QL skills in history, by using spreadsheets, graphic organizers, and collaborative (e.g., Case Study) learning activities to help students improve their QL skills.

The purpose of this action research is to evaluate the effectiveness of graphic organizers using student-relevant data, and spreadsheets as a mindtool, on the quantitative literacy skills of 11th grade students enrolled in a US History II Honors enrolled at SHS. The two research questions are:

1. How does the implementation of the use of advanced graphic organizers and the use of a spreadsheet to manipulate authentic data impact the quantitative literacy skills of 11th grade US History II Honors students at SHS?
2. What are the students' perceptions about the effectiveness of incorporating authentic data sets into graphic organizers in order to increase their quantitative literacy skills?

Research Design

Since the purpose of the research is to improve my own teaching practice by applying new pedagogical strategies and to improve learning for the participants through new learning strategies, action research is an appropriate research procedure. According to Buss and Zambo (2007), action research is an opportunity for researchers to examine their own practices and try new techniques, pedagogies, and technologies to improve on a specific aspect of their practice. Action research is for scholarly practitioners "who use practical research to address existing persistent issues within their respective contexts with the purpose of improving teaching and learning and/or learning environments" (Arslan-Ari, Ari, Grant & Morris, 2018, p. 441).

Action research (AR) is defined as a systematic inquiry by teachers with a vested interest in learning about how their environment operates (Dawson, 2012) and how changes might affect the environment. Action research is cyclical and follows a

framework that involves different phases: planning, acting, developing, and reflecting (Manfra & Bullock, 2014; Mertler, 2017). Action research is also a process in which a specific problem is identified, and an intervention was designed and tested with a view to gaining insight into the problem and ultimately solving it (Elliott, 2001). According to Johnson (2008), action research is recursive and cyclical, not always producing a planned outcome. After the initial research has been conducted, the researcher attempts to modify the intervention to make the next round of implementation more successful.

Mixed methods research, as practiced in this action research, does not attempt to simply define what has already happened by examining data or building hypotheses. Instead, quantitative and qualitative data were collected and examined together, so that both sets of data tell a complete story. Action research is neither non-experimental nor experimental because the researcher does not have control over the variables, but instead, studies them to determine their effect on the environment or problem (Mertler, 2017). Instead, action research seeks to solve a problem, primarily local in nature, that may later be broadened to fit other inquiries. Once the solution to a local problem of practice is resolved, the outcome of the study might be broadened to include larger groups of participants or transferred to another setting with a similar problem.

In mixed methods research, quantitative data are used in deductive analysis of the participants and their activities, while qualitative methods are used to answer questions about experience, meaning, and perspective, usually from the views and feedback of the participants (Hammarberg, Kirkman & deLacey, 2015).

Because action research is geared to a specific problem identified by the researcher in a specific setting, the findings can "reveal new understandings and

knowledge not always readily apparent to outside researchers" (Manfra & Bullock, 2014, p. 162). In this study, the sudden shift to remote learning because of COVID-19 changed some of the intervention parameters. The action researcher also has a variety of analytical tools to choose from and may modify some of the existing surveys and data gathering tools to specifically fit the research needs (Hammarberg, et al, 2015). Finally, action research may result in the alteration of future instruction or produce additional research questions.

In this action research project, I utilized a convergent parallel mixed method design (Creswell & Creswell, 2017). This research methodology collects and analyzes both quantitative and qualitative data together and combines the data together during the analysis process, at roughly the same time. After the individual data are analyzed, the researcher uses appropriate strategies to merge the two sets of results and finally interprets the two sets of results together. "The underlying logic of mixing quantitative and qualitative data is that, on their own, neither method is sufficient to capture the details and trends of the topic under study" (Classen, 2007, p. 678). When used in combination, quantitative and qualitative data complement one another and yield a more complete analysis (Creswell et al., 2004). Windschitl and Wells (1996) elaborate further by claiming "Results suggest that numeric measures tend to elicit deliberate and rule-based reasoning from respondents, whereas verbal measures allow for more associative and intuitive thinking" (p. 343).

This action research examined the effects of using graphic organizers and spreadsheets to enhance student learning of quantitative literacy skills. The research design reflects the "various interrelated elements that reflect its sequential nature"

(Bloomberg, 2016, p.65). The research began by collecting demographic data and pretesting the QL knowledge of the participants to create a baseline for analysis and to refine the goals of future individual intervention units. The research began with the collection and analysis of quantitative data, in the form of a participant survey and a pretest-posttest to determine the effect of the intervention on student learning. After the intervention began, both quantitative and qualitative data were collected as various data were collected about the intervention lessons. Finally, a focus group interview was conducted with eight participants to add to the corpus of qualitative data.

The action research format allows for flexibility in collecting and interpreting student data. Student responses to the initial demographic survey and the performance on the pretest, allowed for some manipulation of the intervention delivery to ensure that excessive time was not spent reteaching basic concepts, or what the participant group already knew. The nature of the action research format allows changes to be made for subsequent iterations of the research based on the interpretation of ongoing responses and adjustments made to the intervention based on the new parameters (Mertler, 2017). The original quantitative and qualitative analysis, in fact, revealed student thoughts and attitudes not previously considered, which required a review of the original purpose and questions during the next iteration of the action research cycle.

Setting and Participants

This action research project took place at a suburban high school located in Northern New Jersey. The high school enrolls approximately 805 students, of whom 74% are Caucasian, 15% are Hispanic, 5% are Asian, 4% are African American, and 2% are listed as “Other” or “Multiple” ethnicities. The student population is approximately

51% female and 49% male. Approximately 16% of the students are classified, with 15% having an Individual Education Plan (IEP), and 5% a 504 Education Plan. The District is considered upper-middle-class by the NJ Department of Education (NJDOE DFG, 2004) and almost all the students have cellular telephones and wireless internet access (WHS Chromebook Survey, 2018).

Of the 66 students I teach this year, 77% are White, 11% are Asian, 5% are Hispanic and 3% are African American. Of the 66 students, 65% are male and 35% are female, and three of the students have an IEP or 504 plan. In the US History II Honors class in which the research was conducted, there were originally 19 students: 53% are male and 47% are female. White students comprise 84% of the class, with Asian and Hispanic students representing 11% and 5% respectively. There are no students with special education accommodations. One female, Hispanic student enrolled one month after the year started and declined to join the participant group.

Of the 19 students in the original target population, four were fully remote at the start of the first semester of the 1920-21 school year and the remaining 15 originally were in class every other day, based on a roughly equal assignment of students to either Group 1 or Group 2. On days when Group 1 classes physically met, Group 2 students and the fully remote students joined the class online via Google Meet. Based on the normal, Pre-COVID-19 schedule, each class would have met on average four times per week, with remote students online for all classes and Group 1/Group 2 students meeting physically for two of the classes, and remotely for two.

The intervention lesson plans and learning tools were designed for use in a normal school setting with all students physically present. For the past eight years we have used

block scheduling with 55-minute blocks of instruction, starting classes in the fall on a rotating schedule, with different rotations before and after lunch. The US History II Honors class was scheduled during period eight for Academic Year (AY) 2020-21, which means they met in the afternoon, with rotating start times at 12:00, 1:00 and 2:00 PM, with the fourth day as a "dropped" class. Based on the original schedule, each period would meet for 15 hours per month, or on average for 3.75 hours per week.

The current school year is "Year Two" of a 1:1 Chromebook Initiative, where each student has been issued a Dell Chromebook, with an 11.5" display for their daily personal and educational use. New Chromebooks are purchased each year, and the incoming freshmen are given new Chromebooks to use for their 4-year high-school experience. Staff training to effectively use the Chromebooks for student learning is currently ongoing, primarily through Professional Development involving Google Education products and personal engagement with external Professional Development and training. Student daily and long-term assignments are generally posted in Google Classroom, where students also have access to online textbooks and supplemental material posted by teachers for lesson delivery.

The research was conducted in one US History II Honors class, open to juniors, who were asked to participate in the study. Students must be recommended by their US History I Teacher, or waived into the class by their parents, with approval of both the Guidance Counselor and appropriate grade level administrator. Each year the course is taught with a different overall theme, with past themes including citizenship, cultural changes, ideological changes, and immigration issues. The theme for all of my upper-level history courses (AP and Honors) this year is "History by the Numbers", which

involved studying charts and graphs to support the study of US History. Success in class this year depended heavily on a student's ability to interpret charts and graphs, which is one of the primary goals of quantitative literacy (Geiger, Forgasz & Goos, 2015), as well as to interpret numbers, apply numbers correctly and use precise data.

The research was conducted in one high school classroom, Room 134, and online. The classroom is equipped with a 77-inch Epson Smartboard, instructor Dell personal computer station, and whiteboards along the back wall which physically extends student participation when they are in the classroom, but the primary day-to-day teaching and learning involves the use of the Chromebooks for student activities. Most of our instruction is done via Google Classroom and the students are generally proficient in Google Docs, Sheets, Slides, Gmail, Sites, and Forms (for both formative and summative assessment). Following two of the intervention lessons, Padlet was used as a software tool to allow students to demonstrate proficiency in a skill or concept that we covered in class.

In September 2020, we began the year operating on a hybrid schedule in response to the COVID-19 crisis. The hybrid schedule involves a rotating schedule, which is described here for the US2 Honors class in which the study was conducted. The class, Period 8, is divided into two groups, each containing both in school and remote students. Group 1 contains students with last names beginning with A-K, and Group 2 contains students with last names beginning with L-Z. On Mondays and Tuesdays, periods 1-4 meet in school, and on Wednesdays and Thursday's periods 6-9 meet in the school. On Mondays, Group 1students in periods 1-4 are in school, and on Tuesdays, Group 2 students, in periods 1-4 are in school. The same schedule is repeated on Wednesdays

(Group2, periods 1-4 in school) and Thursdays (Group 2 6-9 in school). Group 1 students are in the classroom while Group 2 and fully remote students are at home. Once every four weeks, on Fridays, one of the groups gets an extra one-hour session either online or in-school. All students meet together remotely on Tuesday afternoon for 35 minutes. The fully remote students join the class via Google Meet each time the class is scheduled.

The participants for this study were selected from the high school juniors enrolled in the single US History II Honors class. Participants from the class were slightly mixed in terms of academic achievement, but mostly from the upper quintile of the class. US History II Honors, which covers material from Reconstruction to the Modern Era, is a required course. Although enrollment numbers vary from 13-23, the US History II Honors (US2H) course has one section in 2020-21 with 20 students enrolled. The population for this study includes the 20 juniors enrolled in the Honors level course.

The participants for this convergent parallel mixed methods action research project were purposefully selected from those students enrolled in the course, and who volunteered to participate. Fourteen of the 20 students ultimately agreed to participate in all aspects of the research project. Regardless of their participation, all US2H students received the same planned instruction, but nonparticipant data were omitted from the research data collection and analysis. While all student data were not analyzed for the project, the data are still valid for consideration when considering design changes to the course for next year.

Students, parents, and staff were informed that participation was completely voluntary and did not play a role in a student's grades or performance assessments. One student volunteered, but the parents refused to sign the consent form, without giving a

reason. The study's purpose is to determine student perception of pedagogical changes in the use of technology, including the spreadsheet and graphic organizers, so a wide variety of inputs were collected. Table 3.1 below describes the participant group (*n = 14)* with regard to their pseudonyms used in the data analysis, age, and level of participation (all activities and focus group participants).

Table 3.1. *Profile of Action Research Participants (n=14)*

Name (pseudonym)	Age	Gender	Focus group
Bethany	16	Female	
Billy	16	Male	Yes
Buck	16	Male	Yes
Charlotte	16	Female	
Christian	16	Male	
Cicely	16	Female	Yes
Claudia	16	Female	Yes
Edgar	16	Male	
Jack	16	Male	
Jill	16	Female	Yes
Mary	16	Female	
Samantha	17	Female	Yes
Sissy	17	Female	Yes
Tom	16	Male	Yes

Intervention

I used a convergent parallel mixed method design (Creswell & Creswell, 2017) to determine the impact on student's quantitative literacy (QL) skills after applying the intervention, and their perception of the practices. While each of the students had access to the same basic classroom technology described earlier, their response to new pedagogy and learning activities was received differently at the individual level, based on the various processing of new information (Anderson, 1978; Ausubel, 1963, 1968). This intervention utilized Google [spread] Sheets as a Mindtool, authentic data that was

directly meaningful to students and instructor-created graphic organizers to engage students in student-centered learning regarding QL skills and to evaluate the effect on student engagement and retention.

In the study of US History, significant amounts of historical data are presented numerically, and as a result, there are several fundamental charts and graphs to understand. Historians, textbooks, government entities, organizations, and companies use a variety of bar, line, and pie charts to display data and create specific meaning for their viewers. Understanding this data has its own mathematical requirements, including interpreting large numbers in government reports, and viewing charts on various types of tables, graphs, and charts. Many of the charts are difficult to understand because of unfamiliarity with the terms used in describing the material. The delivery of all intervention lessons was included in the scope of the regular classroom instruction in US History II honors, because the theme for this year was "History by the Numbers", which was preplanned to focus on the interpretation of numerical data while studying history.

The intervention incorporated several components of QL, focusing primarily on the creation, interpretation, and manipulation of historically themed data, charts, and graphs. The underlying skills needed for the intervention involved the creation and editing of data in a spreadsheet, the application of methods to simplify and enhance data analysis, and the use of certain school-based mathematics skills to solve real-world problems. Social studies and economics frequently use charts and graphs to provide visual reinforcement for textual ideas and to suggest trends and relationships that are difficult to explain with words only (Gallavan & Kottler, 2007). Charts and graphs not

only display data, but they also tell stories, which the reader must be able to uncover and decipher:

> The learning outcomes sought by social studies educators emphasize the ability and inclination to think critically in ways that combine deep content knowledge with an understanding of how knowledge in the disciplines of social studies is created and how it changes (Rudnitsky, 2013, p.1).

NJ Statute 6A: 9-3.2 states that every teacher, regardless of their course assignments, “understands the concepts inherent in numeracy (mathematical literacy) to enable students to represent physical events, work with data, reason, communicate mathematically and make connections within their respective content areas in order to solve problems” (N.J.A.C. 6A:9, 2011, p. 21).

Additionally, students have difficulty translating numeric concepts and formulas learned in the classroom to real-world situations (Steen, 2001), and the overall curriculum requires them to do so frequently. According to NJ Statute, the “teacher realizes that content knowledge is not a fixed body of facts, but is complex, culturally situated and ever-evolving. He or she keeps abreast of new ideas and understandings in the field” (N.J.A.C. 6A:9, 2011, p. 21). It is incumbent on non-math teachers to foster QL awareness in other areas of practice to ensure that students can make real-world connections (NAASP, 2017).

Mindtools

Mindtools are computer-based applications that enable or require students to engage in higher-order cognitive activities, such as creating, extrapolating, and analyzing

data (Jonassesn, 2000), and help users transform information into knowledge (Kirschner & Erkens, 2006). Specifically related to spreadsheets, Kirschner and Erkens (2006) stated:

> In using a spreadsheet, learners design, use, and fill in values and formulas requiring them to use existing rules, generate new rules to describe relationships, and organize information, engaging critical thinking in them and forcing learners to think more deeply (p. 201).

For this intervention, Google Sheets was the primary spreadsheet application because the participants have access to it through the Google Suites application on their personal Chromebooks. Using the Google Sheets application also reinforced work done in other classes and allowed the students to have constant access to the files in the Google Drive cloud storage.

The intervention was conducted using Google Sheets to input and create numeric models, based on authentic data which was of specific value to the students, for both present and future activities. In other words, when the class was studying the Cross of Gold speech from 1896, the students viewed data, charts and graphs on silver production, ratios between gold/silver, and maps that displayed Congressional voting patterns, rather than simply analyzing the 1896 speech by William J Bryan. The data were manipulated to teach a variety of quantitative literacy skills, including graphing, chart-making, creating numeric precision, data comparison, and applicability.

Graphic Organizers

"Graphic organizers offer visual models that equip teachers and students with tools, concepts, and language to organize, understand, and apply information" (Gallavan

& Kottler, 2007, p. 1). Graphic organizers were used to scaffold the instruction and provide a way for students to analyze data more critically and judge it for precision, veracity [accuracy], usefulness, meaning, and planning. Graphic organizers improve comprehension in ways that conventional prose does not (Decker & Wheatly, 1982; Waller & Walley, 1984) by activating prior knowledge more quickly and completely than the prose (Clarke, 1991; Dunston, 1992).

The role of the graphic organizer is to expand cognitive functioning and processing. Graphic organizers utilize the "arrangement of ideas, facts, concepts, and ideational relationships which are presented visually and independent of a text" (Darch, Carnie & Kameenui, 1986, p. 276), which aids the user in understanding of the hierarchy of information and the relationship of the organizer to the underlying text or concepts. The graphic organizer is intended to provide guiding questions and help students consistently identify both patterns and errors. Graphic organizers also help prevent cognitive overload by identifying important concepts in the beginning of the lesson, thus allowing working memory to focus on other important learning tasks (Anderson, 1978; Ausubel, 1963, 1968)

According to Mayer (2014), students need to engage in three critical cognitive processes in order to gain a good understanding of the information being presented: selecting process, organizing process, and integrating process. Completing a graphic organizer helps students engage in these three processes efficiently (Kendeou, 2014, McCrudden et al., 2007). Adding the task of creating a graphic organizer may overload student's cognitive ability, and may lessen understanding (Colliot & Jamet, 2018), so students completed graphic organizers based on classroom activity, but did not create

them. For this first round of intervention activities, the graphic organizers were researcher generated, focusing on the uses of the spreadsheets and authentic data on student engagement and perception.

Authentic Data

Authentic data is significant, meaningful data that the students are currently exposed to, or that has a current impact on the students' lives which gives purpose and meaning to an activity (Brown, Collins & Duguid, 1989). Examples of authentic data include charts describing income by educational attainment, choropleth maps showing immigration patterns, calculating, and displaying weighted averages, and data that accurately represents financial and economic trends related to the historical period that students are learning.

Organization of Intervention

The actual intervention for this action research study consisted of five intervention lessons, each approximately fifty-five minutes in length, followed by a culminating formative assessment, identified in this text as a case study of the content of all five lessons. The term "case study" is routinely used in my practice to describe a learning activity at the end of a unit of lessons, in which students work in teams to use higher-order thinking activities to enhance their learning about the unit. The case study was completed by the entire class of 20 students, in groups of five, over two 55-minute periods in November 2020. Prior to the intervention lessons, two activities are planned which may have influenced student perception of the intervention efforts. The first activity was a 35-question pretest assessment measuring student knowledge of various components of QL, including numeric precision, percentage, comparisons, chart and

graph analysis, and algebraic formulas. This activity also gave students a preview, or expectation, of what was to follow. The second activity was a preintervention lesson designed to provide participants with enough spreadsheet knowledge to be successful during the intervention lessons. Although the results of these two activities did not alter the planned intervention delivery, they may have some impact on how well the students understand and master the intervention material by revealing areas of need in the participant's required knowledge.

Five intervention lessons were implemented, once a week for five weeks, from October 20, 2020, to November 24, 2020. All five intervention lessons were delivered to a fully remote participant group, based on a move to fully remote status on October 18, 2020, and a second fully remote period beginning on November 11, 2020. This unexpected switch to full remote instruction affected the timing of the instruction, the clarity of both sound and visual displays, and the ability of the researcher to observe participants engaged in the lesson.

After each intervention lesson, participants completed exit slips regarding the material they learned during the lesson. The last intervention lesson was a group formative assessment (case study), where groups of five students, comprised of participants and non-participants, used the material learned in the five intervention lessons to complete an analysis of charts and graphs related to [then] current COVID-19 data, take from the internet immediately prior to the case study. Appendix F has the completed intervention lesson plans and Appendix H contains the Intervention Case Study questions.

Administration of Pretest Assessment

All students, including the study participants completed this assessment during the first week of the intervention, and the results of those assessments were used to help determine student understanding of basic math concepts for the course before the intervention began. Where students collectively demonstrated limited understanding of basic mathematical skills, the length of time spent on specific topics in the pre-intervention lesson was tailored to focus on the areas that students needed most. For instance, most students incorrectly believed that if two pie slices in a pie chart were marked as 33%, each represented identical amounts of money. Students also had problems on the pretest with items related to chart interpretation, so that topic was a point of focus during the preintervention lesson.

The pretest was given to three teachers and four former students at the beginning of the school year, and the group was asked to evaluate the pretest assessment for clarity, question difficulty, and ease of understanding. Based on the feedback, some of the questions were reworded, some of the answer choices were edited and the instructions were edited for clarity. Based on the comments and test results of the seven volunteers who took the pretest, it was determined that none of the 35 questions was unanswerable by the participants in the research project, although both the peer evaluators and research participants had similar scores and missed questions in the same areas.

Pre-Intervention Lesson

The pre-intervention lesson was administered on October 23, 2020, to provide participants with basic spreadsheet knowledge to effectively participate in the intervention. Basic numeric characteristics in a spreadsheet were discussed and then

numbers were entered into a basic spreadsheet and formatted for different representations, such as percentages, currency, and rounding for precision. Students entered data directly from their graphic organizers into Google Sheets using personal Chromebooks, as the instructor entered the data and formulas for the lesson using the Smartboard to demonstrate the skills and desired outcomes.

The lesson discussed basic data entry and manipulation (formatting and analyzing) as well as the default settings for Google Sheets and an understanding of why the information is necessary. The data selected for this activity was relevant to the students, but not necessarily applicable to the current course progression or its curriculum content. Meeting the lesson objectives ensured that students had sufficient underlying knowledge to understand the material presented in the five intervention lessons. The lesson helped students identify the differences between numbers and formulas from math class and recognize the same information outside the math classroom settings. The full pre-intervention lesson plan is found in Appendix F.

Determination of Specific Learning Objectives

Traditional lesson plan objectives included objectives for the specific learning skills and cognitive activities needed for the intervention. Objectives included specific sub-objectives for recognizing and using various types of numeric presentations; manipulating data; creating basic spreadsheets; and analyzing and manipulating charts and graphs. These objectives were created by the researcher in accordance with school lesson planning guidelines and using principles established by Mager (1997).

Using Mindtools to Design Intervention Lessons

Jonassen (1996) offers a list of learning activities that can be accomplished using a variety of computer software programs, which he labels "Mindtools", such as databases, spreadsheets, and artificial intelligence products. In addition, Jonassen believes that students learn *from* computing, *about* computing, and *with* computing as they engage in selected skills or activities (Jonassen 1996). For each program discussed, Jonassen asserts that three distinct types of learning, or thinking, are used: critical thinking skills, creative thinking skills, and complex thinking skills. Before any of these three are applied, students must have mastered the idea of content/basic thinking skills which involve the cognitive ability and disposition to learn accepted information, such as how to use the software, basic numeric relationships, and simple mathematical concepts (Jonassen, 1996). Each of these three higher-order skill sets may be further broken down into processes and individual skills, each requiring different cognitive thinking strategies.

Appendix A is a complete version of the Mindtools matrix for spreadsheets, showing the three main thinking categories with selected processes, and a sample individual skill. The primary tasks associated with spreadsheets are the column headings. Each of the individual skills may be also linked to a specific Bloom's taxonomy function. For instance, in the Evaluating Process, there are five specific skills listed: Assessing Information, Determining Criteria, Prioritizing, Recognizing Fallacies and Verifying.

In all, the spreadsheet Mindtool skills matrix has three higher-level skills, nine general skills, and 45 individual skills listed in Appendix A. Jonassen (1996) concluded that "learning about computing should be situated in the act of using the computer to do something that is useful, meaningful and intellectually engaging" (p. 9).

In Unit 3, for example, when students learned about line charts, they were asked to interpolate and extrapolate data from both a data table and chart, reflecting creative thinking, imagining, and speculating. As students manipulated data and charts, they are employing critical, creative, and complex thinking. Most of the 45 specific skills/tasks from the spreadsheet as Mindtool matrix were addressed in the intervention.

Intervention Units

In a constructivist environment, learners are actively engaged in interpreting the external world and reflecting on their interpretations (Bednar et al., 1991; Ertmer & Newby, 2013; Jonassen, 1996). Computers, and spreadsheets, support reflective thinking when they enable users to comprise new knowledge by adding new representations, modify old ones and compare the two (Norman, 1993). Using the spreadsheet and graphic organizers as the primary tools for mediation of instruction, the intervention consisted of six units of instruction, designed to equip students with appropriate tools for interpreting data around them in their post-high-school experience.

The direct instructional portion of the intervention involved the use of a Smartboard to display the Google Sheets data entry and manipulations and other lesson activities simultaneously to all students. The Smartboard presentations were not a factor during remote learning, as students viewed the contents presented on the instructor's monitor on their various personal device displays, including laptops, Chromebooks, tablets, and cell phones. Although some of the instruction was between the instructor and the entire group of students, some of the intervention learning, including the case study, was collaborative, as students checked with one another to catch up on details. On the remaining class meeting days, not aligned with intervention, the class engaged in the

curriculum required by the high school, aligned with pre-stated curriculum goals, which also included some numeric based instruction.

For each intervention lesson, the students engaged in teacher-facilitated discussion and completed a graphic organizer specifically created to learn and analyze the QL skills addressed in the unit. These organizers initially helped teach specific skills, and later allowed students to use their new knowledge to interpret various graphs and charts. Because of the move to remote and the exigencies associated with online learning, the amount of time allocated to instruction was shortened, and not all the graphic organizer material was covered. When the online intervention first began, extra time was needed for both students and instructor to adjust to the new parameters.

Student observations about the utility of the graphic organizers are crucial for future cycles of the action research. All data in the interventions reflected authentic, meaningful information which applied to the student's current study of history, or future activities and choices, which is the goal of QL learning. Besides considering meaningful data, learners were able to apply other important skills learned in traditional math classes to enhance their quantitative literacy skills. The completed graphic organizers for all lessons are presented in Appendix G.

The units were sequential, each building on the previous unit, culminating in a case study at the end which combined the learning material from the first five units. In brief, the following units were included: a) preintervention instruction on data entry and manipulation; b) basic chart and graph construction; c) creating and analyzing variations of the pie and bar charts; d) analyzing line charts by using premade charts and graphs; e) manipulation and analysis of charts for enhanced meaning; f) examination of choropleths

(maps) and non-standard charts; and g) a summary case study using the skills learned during the intervention. Table 3.2 presents a summary of the intervention units and the completed intervention lesson plans are in Appendix F.

Table 3.2. *Summaries of Intervention Units*

Unit	Unit description	Length
Pre-Intervention	The pre-intervention lesson was conducted to ensure that participants have the basic skills necessary to construct, edit and analyze charts and graphs and their underlying data. Activities consisted of reviewing worksheet default settings, data entry, editing data for precision and clarity, basic formulas and the differences between data, text, and cell formatting. Spreadsheet data used for entry purposes was taken from the demographic statistics for the high school so students could see how they were classified according to school data.	1 Week
1	Basic Charts and Graphs – students entered data provided to them and create basic pie, bar, and line charts. Students recorded information about default settings for each type, including axes scales, spacing, coloring, labeling and data precision. Students determined what type of data each chart is best suited to display. Students were also given historical charts and graphs and asked to analyze them for accuracy according to a predetermined set of requirements. Charts and graphs for this lesson were about education level and salary attainment, so students could compare 2020 with 1920 and see changes in importance of education.	1 Week
2	Advanced Charts and Graphs – students evaluated and manipulated predetermined charts and graphs and identify features about the graphs and how they affect meaning. Students examined maximum/minimum number of data points, coloring, labeling, legends, and other factors in chart creation. Graphs and charts were related to US government spending in the 1920s and how it affected personal spending.	1 Week
3	Line Charts – students used predetermined data to create line charts and then evaluate and manipulate them to understand how change to the chart format can alter/distort/clarify the interpretations of line charts. Much historical trend data is presented in line chart format and students were required to analyze the importance of both X	1 Week

Unit	Unit description	Length
	and Y axis scaling, and their effect on chart interpretation and veracity. The charts reflected the growth of the stock market and the production of silver in the US at the end of the 1800s.	
4	Deciphering Charts and Graphs – students examined published charts and graphs and analyze them for veracity, authenticity, and accuracy. Students used predetermined criteria for examining the charts and graphs and determine a graph or charts overall effectiveness. Students also looked at deliberately misleading charts and graphs and decide why they are faulty. Students examined US immigration charts and other population growth charts as we studied immigration to the US from different parts of the world.	1 Week
5	Evaluating Demographic charts and graphs – students examined various demographic maps, including voting participation, spending patterns and census data to determine their meanings accurately. Students examined various methods for highlighting and hiding data in charts and graphs and evaluate the effect of context on interpreting charts and graphs. The maps for this lesson were choropleth maps showing the dispersion of ancestry groups across the US from the Census Bureau, and population pyramids from the 1920s and 2020s.	1 Week
6	Case Study – Students in groups of five evaluated aspects of the COVID-19 virus by evaluating charts and graphs that were presented during the pandemic period and determine their veracity, authenticity and meaning. Students used all the tools learned during this intervention to correctly identify accurate and misleading charts and identify flaws/misinformation in the charts and graphs and the underlying data. The data used for the Case Study was current data from NJ, the CDC and Johns Hopkins concerning trends in COVID-19 and underlying conditions.	1 Week

Data Collection

Data collection began in the fall of 2020 as the intervention was implemented. Quantitative data were initially collected in the form of a brief demographic survey of the participants and a pretest of learning material. Appendix B contains the Student

Demographic Survey. A posttest was administered within a week after the case study to determine if, and what, students learned during the intervention period. The pretest-posttest assessment is available in Appendix C. Exit slips were administered at the end of each lesson to collect student feedback on lessons learned during that intervention lesson. Finally, a focus group interview was conducted with eight of the participants to elicit their perspectives about the effectiveness of the intervention. The Focus Group Interview Questions and Protocol are in Appendix D.

After reviewing appropriate literature reviews on the research topic (Bloomberg & Volpe, 2008) and completed postgraduate coursework, the following methods of data collection were chosen for this action research project. To obtain data for this research study, five primary collection tools were used: surveys, pretest-posttest assessment scores, a focus group interview, exit slips, and informal observations. Table 3.3 represents the exact alignment of the data collection procedures to the research questions. An informal journal was maintained regularly, collecting "impressions, reactions and other significant events that may occur during data collection" (Rudestam & Newton, 2007, p. 111) to gain additional insight when interpreting the data. Because of the nature of mixed methods research, the proposed data collection instruments were modified after use to accommodate new discoveries to be implemented in the next iteration of the action research.

Mixed methods research is an approach "in which the researcher gathers both quantitative (close-ended) and qualitative (open-ended) data, integrates the two and then draws interpretations based on the combined strengths of both sets of data to understand research problems" (Creswell, 2014, p. 2). In the convergent parallel mixed method, both

qualitative and quantitative data are collected at the same time, and the results are connected at the end of the study (Snelson, 2016).

Table 3.3. *Data Collection Techniques for Action Research*

Research Question	Data Collection
RQ 1: How does the implementation of the use of advanced graphic organizers and the use of a spreadsheet to manipulate authentic data impact the quantitative literacy skills of 11th grade US History Honors students at WHS?	Pretest-Posttest Assessments Exit Slips Student Survey Observations
RQ2: What are the students' perceptions about the effectiveness of incorporating authentic data sets into graphic organizers in order to increase their quantitative literacy skills?	Exit Slips Student Survey Focus Group Interview Observations

Administration of Data Collection

Because this was a convergent parallel mixed method study, quantitative and qualitative data were collected together as each data collection instrument was completed, in the order the instruments occurred. The first data collected from the student survey was quantitative, as well as the second set of data from the pretest. Qualitative data were collected in the form of exit slips, and the type of data collected varied as is the nature of the convergent parallel mixed-method study design. This section reviews data collection as units, for instance, discussing pretest-posttest assessments as a whole activity, even though they were separated chronologically. In order, the units discussed are: (a) student

pre-intervention survey, (b) pretest-posttest assessments, (c) focus group interview, and (d) exit slips. Informal observations were also a part of the data collection, but the contents have been interspersed into different areas of the study where they are appropriate and add to data analysis.

Student demographic survey. A survey design provides a quantitative description of trends, attitudes, and opinions of a population, or tests for associations among variables of a population, by studying a sample of that population (Creswell & Creswell, 2017, p. 147). The descriptive statistics from the survey were used to aggregate and analyze demographic data about the participants. The analysis of the quantitative data yielded descriptive data about each question, which in turn were useful to explain or modify specific responses to the analysis of the research questions.

Prior to the intervention, a student survey was administered to collect demographic data, including gender, math and science experience and level, and other information which helped explain the student's perception of the effects of the intervention lessons. Other questions were about the student's spreadsheet and number calculation experiences. Questions 9-15 asked about student career plans in fields that require significant levels of quantitative literacy. The responses were intended to add additional evidence for the analysis of the other quantitative collection tools and add to the richness of the qualitative analysis. The Student Pre-Intervention Survey questions are presented in Appendix B.

Pretest-posttest assessment. The actual pretest is an instructor-created Google Forms quiz, which evaluates students' knowledge of the topics which were covered during the intervention. The assessment was created by the researcher and was peer

evaluated by three teachers at SHS – one elementary, one social studies, and one special education. A teacher from outside the district took the pretest but omitted several questions and the results were not included. Four former students, out of nine asked, took the pretest as well. These tests were given in the second week of the course, before the administration of the preintervention. Based on peer feedback, some of the questions were edited for clarity.

For both assessments, feedback was instantaneous for the students and instructors and may be used to quickly inform or adjust future instruction. Trends may be identified about which specific topics should be covered more thoroughly during the intervention period and which can be improved with minimal instruction, or learning.

Collecting data and monitoring student progress is an essential part of decision-making in education (Hojnoski, Gischlar, & Missall, 2009, p.32). Data from diagnostic, formative, and summative assessment is useful for making connections about student improvement (Green & Johnson, 2010). Pretest-posttest assessments are useful when comparing the impact of an instructional intervention (Boyas, Bryan & Lee, 2012), although there are several biases that may affect the analysis, including the instructor teaching towards the test, giving the test under dissimilar conditions, and not accounting for outside factors which may skew the data (Boyas et al., 2012). The assessments were created by the researcher and were based on information gathered from the performance of previous groups on questions about chart and graph usage. This prior knowledge allows for considering assessment questions that added meaningful context to the data collection (Green & Johnson, 2010). Assessments were validated by sharing them with colleagues and another educational professional.

The pretest-posttest assessments were the same instrument. Students took the pretest assessment in class and were not allowed to keep the assessment or review the correct answers after completing the pretest. The posttest was given six weeks later, and the students were less likely to recall the original questions after six weeks. At the end of the posttest, students were given the opportunity to reflect on how/why they answered questions differently on the second iteration of the test. After seeing the questions, they may have discovered new techniques or were aware of new information to determine answers. Much of the information, may be repeated in the focus group interview, but the alignment of ideas between the events strengthened data analysis and conclusions. By using the same assessments, retention can be related to both specific questions and groups of questions. A copy of the Student Pretest-Posttest Assessment is located in Appendix C.

Focus group interview. Interviews are methods of data collection where an interviewer asks a participant questions, usually in a face-to-face setting (Polit & Beck, 2006) and are among the most commonly used qualitative research data collection tools (DiCicco-Bloom & Crabtree, 2006). Focus group interviews are generally conducted in groups of 6-12 individuals and count on group interaction to produce data that might be missed in individual interviews (Agar &McDonald, 1995; Greenbaum, 2003). "Focus groups are a form of group interview that capitalizes on communication between research participants in order to generate data" (Kitzinger, 1995, p. 299). The interviewer maintains control of the interview through the presentation of the questions but should contribute little else to avoid influencing participant responses (Melia, 2000).

The interview allows the researcher to gain information that often lies between the responses to survey questions and may provide rich data and possibilities for emergent research questions. In focus groups, peer interaction often uncovers evidence that might not be generated or revealed in one-to-one interviews (Guest, Namely, Taylor, Eley & McKenna, 2017). In this research project, student voices should be heard, as the goal is to analyze the impact on them made by changes made to their learning activities. "Since computers were introduced in schools…over 30 years ago, the voices of those who meant to be beneficiaries of the technology have to a large extent remained silent" (Davies, 2011, p. 71). Focus groups also assist with data and method triangulation because they facilitate the interpretation of quantitative data and enhance the depth of the more structured responses yielded by a survey (Stewart & Shamdasani 2015).

One group of eight students participated in focus group data collection, selected from the group of 14 study participants. The group was purposefully selected to mirror the demographic makeup of both the participant group and classroom students. The group was selected to increase the likelihood that responses would be broad and varied. The focus group interview was recorded using Google Meet, and the video file was used to ensure accuracy in coding. Each of the students was presented with a list of 12 open-ended questions, which were read in the order they were written after the rules of engagement were read and the ground rules for participation were reviewed. Students electronically signed a form that indicated they understood the rules of participation and were willing volunteers. The researcher was able to focus more on listening than writing responses because of the video recording and made sure that all students are engaged and responding.

The focus group was conducted in the researcher's classroom, with one student (Billy) present in the room, while the other participants were in remote locations. Billy observed the interaction on the classroom Smartboard, and participated via the researcher's webcam microphone, which provided an acceptable level of communication. The researcher observed from the teacher's computer station. The interview took place from 10:05 am to 11:05 am and was ended on time because students needed to get to the next class, and another class was coming into the interview location. The Focus Group Interview Questions and Protocol are found in Appendix D.

Exit slips. In an ongoing effort to gather timely student feedback, exit slips were collected at the end of each lesson conducted during the intervention. The exit slip is considered a formative assessment and can be used to tailor future lesson plans, gather important student feedback, provide quick feedback, and have the students feel involved in the planning of their own instruction. By utilizing a formative assessment process that is teacher-owned, student-focused, and data-driven, professional learning community teams can move forward in making necessary reflective changes to ensure that all students can succeed (Sterret, Fiddner & Gilman, 2010). Exit slips, responded to by students at the conclusion of the class, provide some insight into the ways in which students have processed the content learning, and can provide the teacher with a focus for the next lesson (Vacca, Vacca, & Mraz, 2011).

All of the exit slips were created and administered using Google Forms. Each exit slip asked questions specifically about the lesson and about overall ideas of learning. Each exit slip contained a different number of questions, some multiple-choice questions that applied the lesson's concept, some Likert type questions that reflected the student

understanding of the lesson content, and written responses that allowed the participant to demonstrate understanding in their own words. Completed exit slips for each lesson are in Appendix E.

Data Analysis

Data analysis took place throughout the action research, using both quantitative and qualitative methods. The nature of convergent parallel mixed methods research is to conduct both types of data collection concurrently, but to analyze them separately until the two can be merged at the conclusion of the data analysis activity (Creswell, 2014). The qualitative data can be used to corroborate or refute the quantitative data. In this case, the difference in the pretest-posttest assessments was thought to be the added intervention of the spreadsheets and graphic organizers to help enhance learning, but the analysis of the scores did not indicate that the intervention had a significant difference on the scores. Different types of data analysis were conducted during the intervention, following the Data Analysis plan established in Table 3.4.

Table 3.4. *Data Analysis Methods for Action Research*

Research Question	Data Collection	Data Analysis
RQ1: How does the implementation of the use of advanced graphic organizers and the use of a spreadsheet to manipulate authentic data impact the quantitative literacy skills of	Student Pre-Intervention Survey Pretest-Posttest Exit Slips	Paired sample t-test Descriptive statistics

Research Question	Data Collection	Data Analysis
11th grade United States History Honors students at WHS?		
RQ2: What are the students' perceptions about the effectiveness of incorporating authentic data sets into graphic organizers in order to increase their quantitative literacy skills?	Exit Slips Focus Group Interview Researcher Field Notes	Inductive Analysis

Quantitative Analysis

Quantitative, or deductive, analysis consists partly of calculating both descriptive and inferential statistics from the Student Demographic Survey (see Appendix B). Descriptive statistics, involving the calculations of central tendencies, were used to describe demographic data and make comparisons of data describing the participant group (Mertler, 2017). Descriptive statistics were also used to explain the results of individual pretest-posttest scores. Inferential statistics, specifically the paired sample t-test were used to evaluate changes in participant scores on pretest-posttest activities as the quantitative literacy intervention was introduced into the study.

The purpose of the paired sample t-test was to determine if the interventions affected the change in the performance of participants between the pretest-posttest assessment. The sample size consisted of 14 students, so an alpha level of 0.05 ($\alpha = 0.05$) would be appropriate for comparison and testing the significance of the changes between

the sample means. The IBM Statistical Package for the Social Sciences (SPSS) Version 13, and Microsoft Excel 2016/Office 365 were used to perform the quantitative data analysis.

Qualitative Analysis.

Qualitative data analysis incorporated multiple data analysis techniques in keeping with the mixed-method research design. Table 3.5 provides a complete list of data analysis techniques aligned to the action research questions and data collection activities. Because the research is guided by open-ended research questions, the data analysis led to multiple conclusions from the research.

Inductive analysis was used primarily to evaluate the qualitative data collected during the research. "The primary purpose of the inductive approach is to allow research findings to emerge from the frequent, dominant or significant themes inherent in raw data, without the restraints imposed by structured methodologies" (Thomas, 2003, p. 237). According to Thomas (2003), there are three main goals of inductive analysis, which are similar to other qualitative analysis models. The first is to condense extensive and varied raw text data into a brief, summary format. Second, the researcher attempts to establish clear links between the research questions and the findings derived from the raw data and to ensure these links are both transparent. These findings should be apparent to other researchers and readers. Lastly, the findings may be used to develop a theory about the underlying structure of experiences or processes which are evident in the data.

An inductive approach was used because the outcomes of the qualitative data were unknown when the data collection and analysis began (Elo & Kyngäs, 2008). In the

inductive approach, “codes, categories, or themes are directly drawn from the data” and not from pre-existing codes or prior research (Cho & Lee, 2014, p. 4). According to Mayring (2000), inductive category development begins by restating the research questions, determining codes, categories and themes based on the data, editing, and interpreting the results.

Qualitative data analysis began with the transcription and coding of the data collected in the exit slips and the results of the focus group interview, then analyzed using inductive analysis (Mertler, 2014). “The primary mode of analysis is the development of categories from the raw data into a model or framework that captures key themes and processes judged to be important by the researcher” (Thomas, 2003, p. 238). Inductive analysis involves reducing the volume of data collected by organizing the data into patterns and themes to facilitate the understanding of the data (Parson & Brown, 2002). When formulating categories by inductive analysis, the researcher comes to a decision, through interpretation, as to which things to put in the same category (Dey 1993).

Initially, interviews and observations with participants were coded using an open coding method, with a mixture of descriptive and in-vivo codes emerging from the interview responses. This initial coding was followed by three iterations of coding that reduced and clarified the codes into categories and themes (Bazeley, 2009; Saldaña, 2016).

Delve software (www.delvetools.com) was used to assist in the coding process. Delve is a Computer Assisted Qualitative Analysis Software (CAQDAS) program built to aid in the coding and arrangement of qualitative data, in this case, the focus group

interview transcripts and exit slips. The program was specifically written for qualitative research analysis.

Procedures and Timelines

This procedures and timeline section lays out the phases for completing the project, beginning with the obtaining of the IRB approval, through implementation, data collection, data analysis, final reporting, and follow-up. A narrative of the timeline and procedures is first, followed by the same information in tabular form.

The ten phases of the action research project began in April 2020, when permission to conduct the research in the local school district was applied for (Appendix I: Application to Board to Conduct Study). That permission was granted by the District's Curriculum Committee and School Board on May 08, 2020 (See Appendix J: Board Approval to Conduct Study). The application to the University IRB for permission to conduct the study was submitted by July 09, 2020.

Phase 2 began upon University IRB approval. Participant rosters were obtained from the school district grading program (Genesis), and potential participants and their parents were sent a letter explaining the research and seeking permission for the student to engage in the research. Letters were sent by US Postal Service and e-mails through the districts' school email system.

Phase 3 began in September 2020 after the staff and faculty returned to school. Much of the first week in school for veteran teachers is devoted to personal preparation and several teachers were contacted to participate in peer review of lesson plans, exit slips and to help validate the pretest-posttest.

Phase 4 began with the arrival of students for the fall semester of Academic Year 2020-21, during the second week of September 2020. As part of the normal course introduction, the research project was explained in person to the students and to their parents on Back-to-School Night on Oct 15, 2020. Participant consent forms were reviewed, and all students were given the opportunity to participate. Normal class instruction, which was not a part of the research intervention began in September to ensure the students had a chance to adjust to classroom rules, procedures and teacher nuances prior to the intervention. Consideration was given to ensure that students are not disadvantaged by the dual obligation of the research project and regular classroom requirements.

Phase 5 took place in the fourth and fifth week of school, after some trust and rapport had been established and students had a chance to adjust to the new classroom environment. A student demographic survey was given to all students, which sought to determine data about their math and business classes and technology usage. This information was useful to the researcher because it provided insight into how student's pre-math knowledge and technology skills might affect their quantitative literacy skills, or how they obtained them. The pretest assessment had a variety of questions about all the skills they would be learning during the intervention phase.

Phase 6 contained the delivery of the preintervention lesson which is necessary for students to participate in. The skills covered in the preintervention lesson were crucial for the students to build on as they attempted to develop quantitative literacy skills using advanced spreadsheet techniques for interpreting charts and graphs.

Phase 7 was the second-longest phase of the research project, six lessons over six weeks, following the lesson plans described in the intervention design section, located in Appendix F. Each week, participants were engaged in unique lesson plans about some aspect of QL, using spreadsheets and graphic organizers as tools for learning. At the end of each lesson, participants displayed or discussed completed organizers, and completed exit slips for both quantitative and qualitative analysis. All submitted material was scanned, analyzed, and returned prior to the next intervention.

Phase 8 consisted of the administration of the posttest, which was identical to the pretest. Scores were evaluated, and the tests compared using a paired sample t-test analysis. After the posttest, 8 of the participants engaged in a focus group interview to discuss the intervention in an informal setting.

Phase 9 lasted approximately 10 weeks and was used almost exclusively for data analysis and reflection. The data from the focus group interview was transcribed and coded, then member-checked once for accuracy. Additional data were collected for clarity by informal observation and questions of the participants.

Phase 10 ended the formal data collection and analysis process and contained a presentation of the findings to participants, staff, and administration.

Table 3.5. *Timeline of Action Research*

Phase and date	Inclusion of others	Researcher activities
Phase 1 Prior to the start of the study. May-June 2020	*Collect* District Consent. IRB Consent.	*Analyze* Submit required forms and information.
Phase 2 Obtain participant consent. October 2020	*Collect* Consent forms from students.	*Analyze* Collect forms and code participant data (pseudonyms).

Phase and date	Inclusion of others	Researcher activities
Phase 3 Member Checking. October 2020	*Collect* Peer comments on exit slips and pretest. Peer comments on lesson plans.	*Analyze* Peer feedback.
Phase 4 Explain research and intervention to participants. October 2020	*Collect* Handout explanation documents for expectations of research participants.	*Analyze* Collect participant questions and answer.
Phase 5 Pretest and Survey. October 2020	*Collect* Student demographic survey. Student pretest.	*Analyze* Analyze results of the survey. Record and grade pretests.
Phase 6 Preintervention Lesson. October 23, 2020	*Collect* Student graphic organizers. Student exit slips.	*Analyze* Exit Slips. Graphic Organizers.
Phase 7 Lesson Interventions. One lesson per week for six weeks. October 30, 2020, to November 24, 2020	*Collect* Weekly exit slips. Weekly Graphic. Organizers. Field Notes. Informal Observations. Peer Observations.	*Analyze* Begin to organize and code data from exit slips and completion of the graphic organizers.
Phase 8 Posttest and Focus Group Interview. December 09, 2020- December 10, 2020	*Collect* Posttest results. Audio record the focus group interview. Final edits on questions.	*Analyze* Perform paired sample t-test analysis on pretest-posttest. Begin to transcribe audio and have member checked.
Phase 9 Data Analysis . December 10, 2020, to March 2021	*Collect*	*Analyze* All sources of collected data.

Phase and date	Inclusion of others	Researcher activities
Phase 10 Data Presentation. May 2021	*Collect*	*Analyze* Present findings to district administration.

Rigor and Trustworthiness

Rigor and trustworthiness in a convergent parallel mixed-methods study require that the data be evaluated together – that the results of the quantitative data be enriched or added to by the qualitative analyses, "in short the data analysis of one data set informs the data collection of the other data set" (Creswell & Creswell, 2017, p. 237). If the data is in fact reliable, the crosschecking of the various data results should produce a more meaningful conclusion (Creswell & Creswell, 2017). Multiple iterations of the activities involved in the research, such as memo-writing, close reading, and rereading and active coding (Boeije, 2002) help gain multiple perspectives of the data analysis and support the idea of the constant comparison method (Mertler, 2017; Strauss & Corbin, 1998). To facilitate data organization, memo-taking, reflection and journaling were used to assist in developing the themes from the qualitative data. Other informal thinking activities should also be included in the research intervention, especially if the interventions are not stimulating learning. "All kinds of aids, such as memo writing, close reading and rereading, coding, displays, data matrices and diagrams support the principle of comparison" (Boeije, 2002, p. 391). Before data analysis began, I asked peers to review the focus group interview protocol and exit slips to help make sure the instruments accurately reflect the purpose and research questions associated with this action research (Creswell & Creswell, 2017). Based on their feedback, a few of the questions were slightly edited for clarification.

Quantitative Analysis

For quantitative rigor and trustworthiness, **a**ccording to Mertler (2017), action researchers should be "most concerned with evidence of validity based on instrument content" (p. 155). This evidence is based on the relationship between the content assessed in the data instrument and the characteristic it is trying to measure. The instrument is valid when the instrument questions relate exclusively to the research topic or questions. Validity can be assessed through peer and expert review of the questions in the instruments (Mertler, 2017).

This was accomplished by administering the pretest-posttest assessment to four faculty members and four former students. The answers to the questions were evaluated and examined for questions that no one answered correctly. I also asked the faculty members to comment on question wording and appropriateness level and edited the pretest-posttest before using it based on those comments and findings. The results for the pretest assessment for the staff was a mean of 71.43, with a *SD* of 21.57, while the student's scores were (M = 70.29, SD = 14.93).

Qualitative Analysis

When analyzing qualitative data, different steps are used to check for validity and reliability. According to Mertler (2017), qualitative validity means that the researcher checks for the accuracy of the findings, while qualitative reliability indicates that the researcher uses methods consistent with similar research to strengthen the findings. Establishing validity and reliability in qualitative research involves checking for these attributes during and after the data is collected. "Without rigor, research is worthless, becomes fiction, and loses its utility. Hence, a great deal of attention is applied to

reliability and validity in all research methods" (Morse, Barrett, Mayan, Olsen & Spires, 2002, p. 2). Morse et al. (2002) also asserted that "In seminal work in the 1980s, Guba and Lincoln substituted reliability and validity with the parallel concept of "trustworthiness," containing four aspects: credibility, transferability, dependability, and confirmability" (p. 3).

In this section on qualitative analysis, the methods of analyzing data for validity and reliability are discussed in the following order: (a) Triangulation, (b) member checking, (c) thick, rich description, (d) peer debriefing, and (audit trail).

Triangulation. Mertler (2017) describes triangulation as aligning the observation of a participant doing something in an intervention with what the participant told you in an interview, and how the participant performed on an assessment or responded to a survey. In other words, all evidence from data collection supports the remaining evidence. "Reliability is gained by the consistency of judgment in observation, labeling and/or interpretation" (Anastas, 1999, p. 416). Reliability then reflects replicability: would another person with the same materials reach the same conclusions or coding decisions (Boyatzis, 1998). Finally, the concept explained by Bazeley (2009) as "describe, compare and relate", was utilized to reflect on the coding and theme development process to create conclusions that are reasonable to the reader. Using multiple sources of interpretation ensures trustworthiness in the data analysis.

Each of the participants engaged in the intervention lessons and submitted their completed graphic organizer along with a completed exit slip before they left the classroom or Meet. The graphic organizers and exit slips were "submitted" by the students in Google Classroom, which allowed me to view their work. Classroom

observation notes and informal conversations provided additional evidence of the participants grasp of the material. At the end of the last intervention lesson, students took a posttest which showed an overall increase for the participant group. Finally, selected participants were able to discuss the intervention in a focus group setting, which added to the quantitative analysis.

A focus group interview after the collection of the demographic data and the final intervention was key in examining the usefulness of the intervention tools. The merging of the qualitative and quantitative data and the interpretation of all the data after the focus group provided enough insight for answering the research questions.

This type of data triangulation strengthens the finding of the data collection activities (Creswell & Creswell, 2017). "To make a claim of trustworthiness, attention must be given to issues of reliability, or the reproducibility of observations or results under the same or similar conditions, and validity, or the defensible assigning of meaning to what was observed" (Anastas, 1999, p. 415). By reproducing the data collection activities under the same circumstances for each iteration of the research, the data collected was strengthened.

Member Checking. Member checking of exit slips and the focus group interview was also utilized to ensure that the recorded data is accurate and reflects the intent of the participants (Creswell & Creswell, 2017). Member checking helps to ensure trustworthiness and credibility of the findings by ensuring that there is congruence between the actual and reported data (Merriam & Tisdell, 2015). Having students randomly reconfirm their exit slip responses after they have been analyzed increases the likelihood that the researcher is accurately capturing what the participants are saying.

Having interview participants spot-check the video recording transcripts also helps to ensure credibility.

Thick Rich Description. Thick rich description techniques were used throughout to capture some of the underlying social and personal interactions observed in the participants affect the outcome of the research. "Thick description refers to the researcher's task of both describing and interpreting observed social action (or behavior) within its particular context" (Ponterotto, 2006, p. 543). The context and setting of the research provided many clues about the effectiveness of a particular action or event and thick, rich description, captured in various ways throughout the analysis process helps make the research claims more understandable for the outside observer or researcher. To describe thoughts and emotions, we need to interpret a situation rather than just describe the surface features. For example, a certain gesture or expression may have many meanings and the researcher must explain the response in context or the reader may not understand (Ponterotto, 2006).

Peer Debriefing. Peer debriefing is the process of interacting with other professionals who evaluate your instruments and help to ensure they meet their intended purpose and are understandable to others. Peer debriefing can be useful in data collection, analysis, and interpretation (Mertler, 2017). Peer debriefing was used in this action research as peers evaluated exit slips before they are used to ensure that they make sense and elicited appropriate students' responses. Peers and former students also helped validate the pretest-posttest assessment to make sure it included material from the intervention and that the students are able to understand the questions. Finally, peer

review was helpful in ensuring the accuracy of the transcription of the focus group audio recording, and in verifying integrity in the coding process.

During the coding process , I shared my coding activities with my faculty advisor, Dr. Arslan-Ari, and she provided invaluable feedback on the coding process, recommending changes for some of the initial codes or grouping of codes into categories. Dr. Arslan-Ari also recommend that I begin the process manually, by creating 3” x 5” index cards and grouping them physically before I began the automated process using Delve tools. Using this process I created groups of codes, which helped in the sorting process, since I did not have a space large enough to work with the cards easily. The grouping activity was helpful in organizing categories and making connections between codes that were not initially obvious to me.

The preintervention lesson was analyzed for content, interaction between instructor and students, and student comments/responses on the initial exit slips. A colleague was approached to observe the preintervention lesson to ensure that instructions about the research project and weekly intervention lessons are clear and understandable. Colleagues were asked to preview the weekly exit slips to ensure that they are clear and understandable from a student perspective. Boyatzis (1998) stated that reliability is also gained by consistency in observation, labeling, and interpretation. These additional, outside conversations helped confirm reliability if our interpretations of the questions coincide.

Audit Trail. An audit trail has already begun on the steps being taken in the intervention process. Thoughts and reflections are recorded, original files and revised versions are stored for easy retrieval. Observations and informal interviews with

participants and peers were reviewed and recorded as they happen before, during and after the action research. Detailed lesson plans, graphic organizers, and exit slips have been created and changes made to them were entered in a field journal. Notes about potential changes to the intervention for subsequent cycles were recorded, in a manner that others could read, follow the logic and potentially recreate. The journal also contains notes on the established teaching/learning techniques, graphic organizers and spreadsheet activities which were presented during the intervention lessons.

The audit trail is also involved with reflexivity or making sure that you are thinking at critical times about the intervention and all the things that influence it and the findings (Mertler, 2017). Reflection on any or all research-related activities are appropriate entries for the field journal. Reflexivity also involves the understanding of the involvement of the researcher in the research, and the interactions between researcher and participant (Dodgson, 2019). As the actual intervention develops, journal notes reflected both expectations and actual results from the intervention. These notes were reviewed and incorporated in the subsequent lessons plans (Mertler, 2017).

Plan for Sharing and Communicating

In the fourth week of the Fall 2020-21 school year (Oct 2020), the scope and nature of the research project was presented to each of the students enrolled in US History II Honors. The presentation included a complete schedule of activities associated with the research, including the expectations for participants. One way to introduce students to data analysis is to use Google Forms to collect data from participants and present them the feedback from their individual and group responses. This activity alone promotes the learning of quantitative literacy skills because it teaches data interpretation

and chart analysis (Geiger, Forgasz & Goos, 2015). Other forms of data collection were used, but it is important to let the students gain some insight into how the data is being used (Bae & Kokka, 2016) and to reassure them of confidentiality (Berg, 2007) while sharing their responses (Bayerlein, 2014). Students can generally see their own responses to the Google Form assessments and surveys, and the group's results without knowing the identify of individual participants (Berg, 2007).

The intervention and other research activities occurred in late September and October 2020, with all activities completed by the second week of December 2020. The end of the first marking period in the fall of 2020 (near the middle of November) offered an appropriate time to provide additional discussion about the progress of the research to participants and explain to students how their feedback is helping to make modifications to the project. Each participant was notified via school email, when the data collection and analysis was completed, and two were asked to provide a brief member check of the revised data analysis after the findings are reviewed.

The department supervisor and district curriculum administrator/Assistant Superintendent were briefed regularly via email and conversation, to gain some peer perspective and alert them to any potential problems or concerns (Berg, 2007). At the end of the third Marking Period of Academic Year (AY) 1920-21 (April 2021), the data collection was completed, coded, and analyzed. At this juncture, it was appropriate to brief the district administration (Superintendent, Assistant Superintendent, and building Principal) online on the research process and the lessons learned to date. At this briefing, steps for the continuation of the next cycle of the research project would be introduced.

Opportunities to present the findings to the entire staff at a District wide Professional Development or Staff Day have been discussed and the research proposal had been accepted as a seminar for the AP Annual Conference in Boston, MA in July 2020 (canceled), and as a session for the Garden State Google Summit in January 2021. The idea has been accepted as a proposal for the NJ Teacher's Convention in Atlantic City, NJ in November 2021, and the Syracuse University Department of Economics Adjunct Faculty meeting in NYC in the fall of 2021.

CHAPTER 4

FINDINGS & ANALYSIS

The purpose of this action research was to evaluate the effectiveness of graphic organizers, using student-relevant data, and spreadsheets as a mindtool, on the quantitative literacy skills of 11th grade students enrolled in an Honors Level United States History course enrolled at SHS. The purpose statement is supported by the examination of two research questions: (1) How does the implementation of the use of advanced graphic organizers and the use of a spreadsheet to manipulate authentic data impact the quantitative literacy skills of 11th grade honors level history students at SHS? and (2) What are the students' perceptions about the effectiveness of incorporating authentic data sets into graphic organizers to increase their quantitative literacy skills?

The intervention was administered to a group of 20 high school juniors in a US History II Honors class. The intervention, planned for a traditional, in-school learning environment, using paper graphic organizers and a Smartboard for instruction, began with students attending class in a hybrid schedule during the COVID-19 pandemic, with one-half of the students in class and the remaining students at home participating virtually. To evaluate the importance of the printed graphic organizers, I printed and mailed the remote students copies of the organizers to use for lessons three, four, and five. By the end of the intervention, the students had all gone into a fully remote status because of the increasing threat from the COVID-19 virus.

Although data were collected from all 20 students, ultimately only the data from 14 participants were included. Of the 20 students in the class, six of the students refrained from having their data included in the analysis but did not state a particular reason for their decisions. Students were asked on three occasions to reconsider participation, but only 14 agreed and returned the necessary parental consent forms.

The results from this convergent parallel mixed method research study are presented in two sections: quantitative and qualitative findings. The quantitative results findings are presented by presenting both descriptive and inferential statistics and analysis for each of the three data collection instruments: a) Student Demographic Survey, b) Pretest and Posttest assessments and c) Likert scale analysis collected in six exit slips conducted during the intervention. Qualitative findings interpret the results of: a) the student written feedback on open-ended questions from six exit slips, and b) the responses to the focus group interview conducted at the end of the intervention.

Quantitative Findings

The quantitative data were generated from three sources: a) responses to questions in the preintervention student demographic survey, b) pretest-posttest scores, and c) post-lesson exit slips. All surveys, assessments, and exit slips were created by the researcher for this specific action research. The survey was created to gain a basic knowledge of student awareness and use of quantitative literacy skills before the intervention. The pretest-posttests, assessed on Google Forms, were given to determine student's knowledge of basic numeracy concepts and the appropriate use of charts and graphs, before and after the six intervention lessons. Quantitative data specific to each intervention was collected after each lesson with exit slips on Google Forms, including

Likert scale and Likert type questions, open-ended responses to gather students' opinions about the tools and concepts used in the lesson, and multiple-choice responses to assess specific learning about the quantitative literacy skills learned in the lesson. Likert types are single questions that use some aspect of the original Likert response alternatives, but no attempt is made to combine the questions into a composite scale (Boone & Boone, 2012; Clason & Dormody, 1994). A Likert scale "is composed of a series of four or more Likert-type items that are combined into a single composite score/variable during the data analysis process" (Boone & Boone, p. 2). Each exit slip had a different number of questions, with at least one, four-response multiple-choice question to determine the participant's grasp of the key concept of the intervention.

Data analysis of the three sets of data were performed with various analytic devices. The demographic data were collected in a Google Form and the descriptive statistics calculated in Excel and verified in SPSS, Version 27. The results of the pretest-posttest were evaluated using a paired sample t-test, calculated initially in Excel, then verified in SPSS. The quantitative data from the exit slips was primarily in the form of Likert scale data and the means, standard deviations, and Cronbach's Alpha were calculated first by hand, then verified using statistical data analysis in Excel, and verified in SPSS.

Data findings and analysis are presented next by presenting the descriptive statistics and inferential statistics from each of the primary data sources, which are: a) student demographic survey, b) pretest–posttest results, and c) data analysis from responses to the six exit slips.

Student Demographic Survey

The entire class of 20 students submitted responses to a Google Forms survey before the intervention began, revealing some of their use/awareness of quantitative literacy skills in various classroom settings. Only the data from the fourteen participants were used in this reporting of descriptive statistics. The survey questions were primarily used to ascertain the basic skill levels of students in the concepts that would be introduced in the intervention lessons.

The survey consisted of 20 questions: Numbers 1-13 were purely descriptive in nature, while questions 14-20 were part of a Likert scale series asking about student use and skill level of various quantitative literacy (QL) skills. The first 13 questions asked basic data about name, age, gender, spreadsheet and calculator use, math course level, and the association of spreadsheet/QL skills with various math and science courses. The seven Likert scale questions are described in the inferential statistics discussion section.

Descriptive statistics. The participants were asked about some of their experiences and practices with the tools and concepts that were presented during the intervention. Seven (50%) of the students were male and seven (50%) were female, with an average age of 16.14 years ($SD = 0.36$). All of the students acknowledged having some spreadsheet experience, primarily in science (79%) and math (57%) classes, and 11 (79%) used their T1-84 calculators for advanced calculations, while three (21%) used their cell phone to perform routine higher-level operations. Some of the information presented during the intervention required some knowledge of basic financial concepts and 12 (85%) of the students had some familiarity with either economics or financial

literacy prior to taking this course. A summary of relevant participant skills is presented in Table 4.1 below.

Table 4.1. *Relevant participant skills (n = 14)*

Question	N	Percentage
Prior Use of Spreadsheet	14	100%
Google Sheets	14	100%
MS Excel	2	14%
Other	1	7%
Courses Using Spreadsheets		
Science	11	79%
Math	8	57%
Online Courses	7	50%
Social Studies	6	43%
English	3	21%
Accounting	2	14%
Economics	1	7%
Means of Calculation		
TI-84 Calculator or Equivalent	11	79%
Cell Phone	2	14%
Basic Calculator	1	7%
Spreadsheet	0	0%
Financial Literacy Courses		
In School	8	57%
Online	2	14%
Accounting	2	14%
None	2	14%

Although all 14 participants claimed to have used spreadsheets prior to the intervention, it was clear based on their questions and feedback during the intervention that their prior spreadsheet use had been rudimentary and did not involve creating charts and graphs. For the most part, students could use Google Sheets as a calculator and perform some basic operations but had not used some of the advanced functions presented in the intervention, such as “if statements” and data sorting/rearranging.

The participants responded to a series of seven questions about their understanding and use of quantitative literacy in the demographic survey. In the Likert-type questions, students were asked about their association with quantitative literacy (QL) issues. Before the survey began, none of the students reported having any recollections of the terms “quantitative literacy”, or “numeracy”, prior to their use in the explanation of the research activity during this course. Eight (57%) of the participants indicated that they were not exploring careers requiring significant QL activity, and nine (64%) reported that they were not comfortable with complex mathematical issues, but 10 (71%) of the students claimed they were comfortable with making financial decisions about their future based on their current QL skills.

Based on the individual question results, the students reported limited anticipation of seeking a career in QL with seven (50%) of the students stating they would probably not pursue a career in the field (DS14), and five (36%) of the students reporting a lack of confidence that they would perform well in a job that relied heavily on QL-skills (DS15), while understanding that math skills are necessary for every job (DS19). Students believed they were above average in basic chart creation and interpretation (DS17, DS18). Students also agreed that technology usage was vital to success in QL related activities (DS20) and were very positive about their ability in making good financial decisions based on their current knowledge of math and QL skills (DS16). The scale response for Questions DS14 to DS20 ranged from 1 (*Not at all*) to 5 (*Very*). Table 4.2 summarizes the response to the questions in the Demographic Survey about QL skills. For the entire seven-question subscale, Preintervention QL Confidence (PICL), the mean

was 3.59 (*SD = 0.99*) with a Cronbach's alpha of .73, indicating that the reliability of the scale is acceptable (Gliem & Gliem, 2003; Tavakol & Dennick, 2011).

Table 4.2. *Participant Level of confidence in their current QL skills* (n=14)

Q#	Question	*M*	*SD*
DS 14	How likely are you to seek a career that is based on mathematics/Quantitative literacy?	3.08	1.50
DS 15	At this moment, would you feel comfortable in a job that relied heavily on math calculations, numeric interpretation, and math-based projections?	3.15	1.34
DS 16	How confident are you currently about making good financial decisions for your future?	4.08	0.76
DS 17	How would you describe your proficiency in creating charts from numeric data?	3.46	0.88
DS 18	How would you describe your proficiency in interpreting other people's graphs and charts?	3.62	0.65
DS 19	Do you feel that mathematical skills are necessary for every job and career you might choose?	3.77	1.01
DS 20	Do increased technology skills make you better able to resolve numeracy (QL) issues?	4.00	0.82

When asked specifically about their ability to use spreadsheets to enter, edit and manipulate data, students were generally more positive about their ability to interpret charts and graphs made from spreadsheets than their ability to create them. Students also felt that the spreadsheet and charts skills were important to the study of US History and to their work careers. Table 4.3 displays the student self-reporting on increased spreadsheet skills and the importance of the learned material. Student did not feel however, that they were able to interpret maps, such as choropleths and population pyramids, as well as other types of charts and graphs.

Table 4.3. *Self-reported improvement in spreadsheet activities.*

Category (Question #)	*M*	*SD*
Interpret graphs and charts more accurately (CS5)	4.50	0.65
Important to Work Career (CS8)	4.21	0.70
Basic Spreadsheet Knowledge (CS61)	4.00	0.88
Interpreting Bar Charts (CS 64)	2.57	0.65
Are learned skills important to study of US History (CS7)	2.43	0.76
Interpreting Pie Charts (CS63)	2.29	0.61
Making Charts (CS62)	2.27	0.43
Using Formulas (CS62)	2.19	0.61
Interpreting Maps (C66)	2.14	0.77

Note: The questions were in the final case study (CS) exit slip and asked students to evaluate in questions CS5 and CS61- CS66 what they had learned over the course of the intervention from 1(*No Improvement*) to 5 (*Significant Improvement*) and CS7-8 were about the importance of the topic from 1(*Not Important*) to 5 (*Very Important*).

Pretest-Posttest Results

An assessment created by the researcher that had been previously used in microeconomics courses at SHS was used for the intervention pretest-posttest. The assessment was revised slightly for the intervention and the revised assessment was given to seven senior high school students and four teachers to ensure that answers were correct, questions were presented correctly and without error, and to verify that the students could understand the questions and concepts. None of the questions on the assessment was unanswerable by any of the test validation contributors.

Both assessments were identical and consisted of 35 questions concerning quantitative literacy skills. The assessments included 14 questions specifically about charts and graph understanding and usage, while the remaining 21 questions were about QL topics, such as percentages, data precision, and similar topics. Each of the skills evaluated on the pretest-posttest assessment was either a subject of direct instruction during the intervention lessons, calculations on an intervention spreadsheet, or a skill

required in the NJ Math Standards for 11th Graders (NJDOE SLS Math, 2017). The pretest-posttest assessment is included in Appendix C of this proposal.

Descriptive Statistics. The pretest was given to all 20 students enrolled in the class on October 22, 2020, during a 55-minute class period. All students took the test online and the date was chosen so that the pretest was administered right before lunch, so students could have extra time to complete the test if needed. The first student completed the test in nine minutes and the last student finished in 64 minutes. Participants took an average of 43 minutes to complete the pretest. The average score (out of 100) on the pretest was 62.45 (*SD = 20.14*). On the pretest, only one question, Question 30, was answered correctly by all participants, and there were 14 questions that 10 or more participants answered correctly.

The posttest was given on two separate dates: December 09 and December 10, 2021. The 12 students who were not participating in the focus group interview on December 09, 2021, took the posttest in lieu of participating in the interview, and the remaining eight students, the focus group interviewees, took the posttest the following day during the scheduled class time. The average time spent on the posttest was 37 minutes, and the mean score for the 14 participants was *68.37 (SD = 13.09)*. On the posttest, there were three questions (Questions 12,18, and 19) answered correctly by all participants, and 23 questions answered correctly by 10 or more participants on the posttest.

Inferential Statistics. A separate paired sample t-test was performed for the entire assessment and then for two subsets of data from the assessment: the 14 questions related to charts and graphs and then again for the 21 remaining questions. The data were

analyzed first in MS Excel (Office 365) and then again in SPSS Version 27. The outcomes for the paired sample t-test were identical for both analyses. The Shapiro-Wilk normality test, histogram, skewness, and kurtosis values were calculated to check the normal distribution for the score differences between the pretest-posttest. For the Shapiro Wilk test, we established a Null Hypothesis (H_0), which states a variable is normally distributed. The Alternate Hypothesis (H_1) is that the variable is not normally distributed, and we rejected H_0 if $p < .05$ (Flynn, 2010; Razali &Wah, 2011). The results of the Shapiro Wilk test concluded that the differences between the pretest-posttest scores for each dependent variable were normally distributed. For the pretest, "$W(14) = 0.951$, $p = .569$" and for the posttest, "$W(14) = 0.948$, $p = .534$". Since three different paired sample t-tests were run, a Bonferroni correction was used to control the Type I error. The Bonferroni correction level was calculated by dividing the alpha level (.05) by 3, resulting in a new p-value of .0167.

The hypothesis that was tested with the paired sample t-tests was whether the intervention resulted in a statistically significant improvement over the pretest. The null hypothesis (H_0) was that the mean difference between pretest-posttest scores is zero, while the alternative hypothesis (H_1) was that the mean difference between the scores is statistically different.

A paired sample t-test was conducted initially on all 35 questions of the overall assessment, and a separate analysis was conducted for the 14 chart and graph-related items and a third analysis was conducted for only the 21 items related to the questions about other QL topics. For the paired sample t-test evaluating the complete set of 35 questions for the pretest-posttest, the results are as follows: $t\ (14) = -1.89$, $p = .08$.

Because the calculated value for p (0.08) is greater than the Bonferroni correction value of .0167, the null hypothesis cannot be rejected, and the differences are not considered statistically significant.

For both tests, calculated with Excel 365 and SPSS 27, the mean scores and standard deviations are as follows: pretest, (*M* = 62.44, *SD* = 20.13) and posttest (*M* = 68.36, *SD* = 13.09). Comparing the posttest mean (*M* = 68.36) to the pretest mean (*M* = 62.44) indicates that the students scored higher on the posttest. However, four student's scores declined between pretest-posttest by an average of -5.75 points, with a range of -2.9 to -8.6, while ten students improved by an average of 13.5 points, with a range between 2.9 and 28.6 points.

Chart related items analysis. After considering the meaning of the t-test score calculated for the overall test, a paired sample t-test of only the responses for the 14 chart-related questions on the assessment was conducted. These questions included items (14-19, 22-23, 25-28, 31, and 33) which may be viewed in Appendix C of this document. The paired sample t-test revealed that students posttest scores for chart-based questions (*M* = 26.73, *SD* = 3.29) were not significantly higher than their pretest scores for chart-based questions (*M* = 23.09, *SD* = 7.05), t (14) = -2.19, *p* = .047. Because the calculated value for p (.047) is greater than the Bonferroni correction value of .0167, the null hypothesis cannot be rejected, and the differences are not considered statistically significant.

Non-chart related pretest-posttest question analysis. The remaining 21 questions on the pretest-posttest assessment were also evaluated with a paired sample t-test. The results for the 21 non-chart-related questions also students scored higher on the

posttest as well, with (*M* = 41.63, *SD* = 11.3) than the pretest (*M* = 38.57, *SD* = 4.47). The paired sample t-test result indicated no significant difference between the non-chart-related pretest-posttest scores, t (14) = -1/.14, p=0.27. Because the calculated value for p (0.27) is greater than the Bonferroni correction value of .0167, the null hypothesis cannot be rejected, and the differences are not considered statistically significant. The differences in all three results indicate that the increase in scores cannot be attributed directly to the intervention, and the Null Hypotheses cannot be rejected.

Exit Slips

Exit slips provided much of the data needed to analyze research questions one and two regarding student's perceptions of using authentic data and learning quantitative data skills. The exit slip questions were asked immediately at the conclusion of each intervention lesson and were used to determine if students learned concepts by asking questions about new skills, and to ask students if they could apply the knowledge, they had just learned.

Three types of questions were used in the exit slips: Multiple choice questions to determine if students could apply the lesson material correctly, Likert-type questions to ascertain student perceptions on an idea or concept, and open-ended questions to gain student insight on conceptual issues. The multiple-choice questions were used internally for the researcher to gain insight into lesson effectiveness, while the Likert-scale and open-ended questions were analyzed in the quantitative and qualitative processes, respectively.

In this quantitative analysis discussion, exit slip analysis covers both a) questions that produced descriptive data and b) questions that produced inferential statistics.

Descriptive statistics. Exit slips, created in Google Forms, were assigned after each lesson in the intervention and after the group Case Study at the end of the intervention. The 50 questions on the exit slips varied in kind: 38 questions asked for student opinions about elements of the lesson using Likert-type questions; eight questions asked students to solve a problem using knowledge gained during the intervention, and four questions required students to write a brief response about something they learned or observed during the intervention lesson. A summary of the question types is shown in Table 4.4 below.

Table 4.4. *Question Analysis on Six Intervention Lesson Exit Slips.*

Lesson	Opinion (Likert)	Problem Solving	Qualitative Observations
Basic Charts/Graphs (L1)	2	2	1
Advanced Charts (L2)	10	1	0
Line Charts (L3)	3	1	1
Advanced Chart Elements (L4)	2	2	1
Choropleths and Pop Pyramids (L5)	5	1	0
Case Study (L6) Exit Slip	16	1	1
Total	38	8	4

For instance, in the exit slip after Lesson 1 on “Basic Charts and Graphs”, students were asked to determine what type of chart would be best used to compare five months of sales at a business. Seven (54%) of the 13 participants responded with “bar chart” and six (46%) of the participants chose “pie chart”. Both of those responses were acceptable, and none of the participants chose any of the incorrect responses.

When asked to consider the level of impact a particular item has on the accuracy of a chart or graphs, students reflected on the lesson and were fairly consistent with their responses. See Table 4.5 below with responses to the significance of six variables that can affect charts and graphs.

Table 4.5. *Factors that affect the accuracy of charts and graphs*

Factor	None	Moderate	Significant
Skill of the Creator	1	4	9
Accuracy of Underlying Data	0	3	11
Accurate Labeling	0	0	14
Chart Near Supporting Data Table	2	4	8
Number of Items Being Compared	0	6	8
Accuracy of the Y-Axis	0	4	9

According to the chart it is evident that students believe that “Accurate Labeling” is most significant to the credibility of a chart and graphs, as 100% of the participants indicated that this was a factor, and that the “Accuracy of the Underlying Data” is also quite significant, verified by 11 students (79%) indicating that underlying data were a factor.

On exit slip three, following the lesson online charts, students were asked to determine the difference in the price of silver, if gold was selling at $20.57 per ounce, and the ratio of gold to silver changed from 16:1 to 15:1. The question was taken directly from our lesson on the Gold Standard in 1896, and the data amounted to using authentic data to teach the QL skill. Only one student (7%) answered correctly, indicating that the price difference was $0.09. Six (43%) of the 14 students answered incorrectly stating the price of silver at 15:1 ratio, and the seven others (50%) guessed one of the other two multiple choice answers.

On exit slip four, students were asked to consider what the most important element to consider when evaluating a bar chart. Twelve (86%) of the students answered correctly – the height of the bars – while one student (7%) each answered, “the number” and the “X-Axis”.

Student opinions about elements of the lessons. The 38 Likert-type questions were designed to elicit responses from students about their perceptions of various parts of the intervention. The questions on each exit slip were unique to the lesson, and most did not represent a theme, or group of similar questions, across the five lessons. The case study contained both Likert Scale series and Likert-type questions about the entire intervention. The 38 Likert-type questions followed the same pattern, and used a five-point Likert Scale, ranging from 1 (Strongly Disagree, No or Not at All) to 5 (Strongly Agree, Yes, Completely). Within the demographic survey and case study exit slips, three subscales were developed, with varying numbers of questions in each subscale. The three subscales measured the following: (1) Pre-Intervention confidence levels of intervention-based skills (PISC), (2) post-intervention spreadsheet confidence (CSOC), and (3) post-intervention skills/application confidence (CSSC). The remaining Likert-type questions asked about other specific intervention topics, including questions about the use of paper vs. online organizers, use of social studies specific maps and graphs, and efficiency of the lessons. Table 4.6 provides the means and standard deviations of the subscales.

Table 4.6. *Measurement statistics for exit slip Likert subscales*

Subscale	# of Questions	*M*	*SD*
PISC	5	4.57	1.32
CSOC	7	3.86	0.75
CSSC	6	3.23	0.66

The results for the subscale are as follows. For the first subscale, (PISC), which asked about student's growth is basic spreadsheet skills, the scale had a mean response of 4.57(*SD* = 1.32). The second subscale, Case Study Overall Confidence Level (CSOC), which asked about newly learned skills, the Mean of the responses was 3.86 (*SD* = 0.75).

The third subscale, Case Study Skills Confidence Level (CSSC), which asked about student's interpretations of charts and graphs, the Mean response was 3.23 (*SD* = 0.66).

To ensure data reliability, Cronbach's alpha was calculated for the three Likert Sub Scales in both MS Excel and SPSS 27. The PISC subscale, consisting of five questions was found to be highly reliable results (α = .833). The CSOC subscale, consisting of seven questions was found to acceptable (α = .738), while the CSSC, consisting of six questions, was found to be questionable (α = .655) in terms of internal scale reliability.

Individual Likert-type questions. There were 20 Likert-type questions that were not part of a scale but asked for student input on their understanding or feeling about intervention-related topics. In exit slip five, students were asked to assess their proficiency in entering basic data in spreadsheets (*M* = 3.53, *SD* = 0.66), and creating a spreadsheet with no errors (*M* = 3.30, *SD* = 0.63). Students indicated in the final Case Study exit slip that they had increased their knowledge in basic spreadsheet entry (M= 3.92, *SD* = 1.02) and entering formulas (*M* = 3.30, *SD* = 0.70).

When asked about the use of paper copies of the graphic organizers compared to the same graphic organizer online, students were unsure about the benefits of the paper version of the organizer in lesson 1 (*M* = 2.92, *SD* = 2.57) and slightly more positive in lesson 2 (*M* = 3.21, *SD* = 2.72). Finally, students felt the use of graphic organizers was beneficial to learning the pre-intervention material with all students choosing a four or five on the Likert-scale (*M* = 4.5, *SD* = 0.55). Students were asked in Case Study Q11 if the graphic organizers overall had helped them learn the associated history lesson, 13 (93%) responded "Yes".

When asked about the use of authentic data during the intervention, students responded favorably that the material used in each lesson was meaningful (*M* = 4.46, *SD* = 0.52). When students were asked if the data used was important to their current study of US History, they responded favorably (*M* = 4.23, *SD* = 0.60) and favorably when asked if the learned skills would benefit their work careers (*M* = 4.23, *SD* = 0.70). A summary of individual Likert-type questions related to the use of authentic data and graphic organizers is shown in Table 4.7.

Exit slip multiple choice questions. Questions were used in the exit slips to determine if students had grasped the lesson key points, such as in exit slip 1, Q3 and Q4, where students were asked to determine if two slices of a pie chart represented equal totals from the underlying data and then to provide an explanation. 13 (93%) of the students incorrectly stated that the values were equal but failed to realize that the pie slices represent rounded figures. In exit slip two, students were asked to determine what a chart was intended to replace, and nine (64%) responded with “Tables”, while two (14%) responded with “Stories”, two (14%) with “Text” and one (7%) with “Labels”.

In exit slip three, none of the students correctly answered a question that was similar to one covered during the lesson about the difference in values using different ratios.

In exit slip four, when students were asked about the most common way to mislead viewers when creating a bar chart, 12 (86%) answered correctly that adjusting the bar height was the most prevalent way to mislead viewers. Also, in exit slip four, students were asked to identify the most important element in a bar chart and 12 (84%) answered correctly that it was the height of the bar.

Table 4.7 lists the individual Likert-type questions students were asked across the intervention exit slips and the mean of their responses, with the Standard Deviation. All questions were based on a score of 1 (*no or not likely*) to 5 (*yes, very likely, or definitively*).

Table 4.7. *Summary of individual Likert-type questions*

Question	Text	*M*	*SD*
Authentic data related questions			
CS, Q11	Did the examples in the graphic organizers help you understand the history topics we have been discussing?	4.71	1.07
ES4, Q1	Did the charts reinforce knowledge you already had about the Gilded Age?	4.00	0.85
CS, Q12	Would the lessons have been as effective if the graphic organizers had used other topics, such as economics, for the chart and graph examples?	3.36	0.84
CS, Q7	Overall, do you feel that the skills we learned are important to use when studying US history?	4.21	0.70
ES3, Q2	Did the charts today help you understand the gold-silver debate better than a lecture/explanation?	3.83	0.72
ES3, Q3	Did the addition of the business cycle chart help you understand the effects of inflation?	3.75	0.45
ES4, Q5	Was today's graphic organizer helpful in understanding trends during the Gilded Age?	3.93	0.88
CS, Q4	Overall, do you feel that you learned meaningful new material during the six lessons presented during the study?	2.57	0.65
Graphic organizer related questions			
ESPI, Q3	On a scale of 1-5 (1 is "Added Confusion", 5 is "Very Helpful"), how did the graphic organizer help you learn today?	4.52	0.50
ES1, Q6	Do you feel a paper copy of the graphic organizer would make it easier to follow during class?	3.14	1.00
ES2, Q3	If you had a printed copy of the graphic organizer, did you find it more useful than the electronic copy?	3.21	0.70
ES3, Q5	Did the graphic organizer enhance learning today beyond the actual presentation with the same line charts?	3.67	0.49
ES4, Q5	Was today's graphic organizer helpful in understanding trends during the Gilded Age?	3.93	0.88

Question	Text	*M*	*SD*
CS, Q10	Was the amount of detail in the graphic organizers helpful in learning the new material?	3.43	0.51

Qualitative Analysis

Qualitative data from the study was collected from the 14 participants from two primary sources: open-ended responses to specific questions on four selected exit slips (preintervention lesson, lesson three, lesson five, and the final case study) and the oral and written responses from eight students in a single, one class-period focus group interview, conducted after the intervention was completed. One of the focus group participants responded completely in writing as agreed on before the meeting, and the other seven were asked to submit additional thoughts in writing during the interview. I used inductive analysis, to reduce the data from the raw text form into codes, groupings, categories, and themes.

After the first manual round of descriptive and in vivo coding, I rearranged the codes into groups based on similarity, such as a group that contained all codes related to Charts and Graphs, and another that related to Graphic Organizers. This step, prior to creating categories, emanated from the way I think, and made the rearrangement of the codes into categories more meaningful and logical for me. The additional step of grouping was part of my analytic process, or heuristic thinking. As noted by Saldaña (2016) "heuristic fluidity is necessary to prioritize insightful qualitative analytic discovery over mere mechanistic validation" (p. 9). The qualitative data were evaluated with respect to the research questions, and care was given to reduce researcher bias and to ensure that the final themes accurately reflected the participants feedback and understanding.

The qualitative data analysis and findings are presented in the following order: a) exit slip analysis, b) focus group interview analysis, c) coding, d) categories and e) themes. The first two sections involve describing actions taken after data collection and preparation for thematic analysis, while the sections on coding, categories, and themes describe how the inductive analysis of participant's responses was accomplished.

Exit Slip Analysis

The data from the exit slips were taken from four open-ended, free-response questions following four lesson interventions: preintervention [skill basics], advanced charts, deciphering charts and a group case study combing the skills and concepts learned in the intervention. Close reading of the responses in the exit slips and collecting the responses to individual questions in a single table revealed patterns in the data before coding began. Thomas (2006) emphasizes that inductive coding begins with close readings of text and consideration of the possibility of multiple meanings. He further states that findings are shaped by the cognitive biases, heuristics, assumptions, and experiences of the researcher conducting the study and analyzing the data. Based on these filters, the researcher makes decisions about the importance of the data" (Thomas, 2003).

For instance, in the preintervention lesson exit slip, students were asked to respond to" What is the most important lesson you learned about spreadsheets or data entry, today"? During the initial reading of the responses to the questions, a generalized response was not detectable. However, when the responses were collected, copied into a table, and printed together, an entirely different picture of the data emerged.

The 12 responses from the students who completed the exit slip for the Preintervention lesson, were first evaluated as individual responses for immediate feedback on the lesson. The responses were later combined with other qualitative data and coded as part of the larger data corpus. This 55-minute lesson was intended to ensure that all participants had basic spreadsheet skills to understand the remaining lessons on charts and graphs. The responses were to the question – “what was the most important lesson you learned about spreadsheets or data entry today”? The responses were asked without any prompting and the student answers varied considerably. Even though it was not the point of the lesson, seven of twelve (58%) students focused on the idea that charts and graphs may be misleading or inaccurate, while only three (25%) reported spreadsheet functions as the most important skill learned during the lesson and two (17%) reported discovering “hidden sheets and charts” as the most important lesson.

The idea that participants focused on the idea that charts and graphs may be misleading is associated with schema theory. When presented with new information that does not fit into their existing schema about a particular topic, new ideas are correlatively subsumed (Ausebel, 1963) into the existing schema. The new idea, that charts and graphs were misleading, was new to many of the participants and they had to elaborate, modify, or extend their existing schema. Identifying the new learning during the exit slip question, indicated that they were considering the new information as a part of a modified schema.

As subsequent information was presented during the intervention lessons, students were able to incorporate the new data, and after the lesson on misleading charts and graphs, and during the focus interview, students identified the concept of inaccurate, or

misleading, charts and graphs as one of the key takeaways of the intervention. Several students during the interview, including Cicely noted that “not all charts are telling the 100% truth & before I would just assume that everything it said to me in the chart was true and completely accurate”.

When the data were presented in tabular form, and the phrases concerning inaccurate charts were highlighted, it became obvious that the inferences in the lessons to chart inaccuracies had made a significant impact on the students. These phrases, such as “a pie chart will never be 100% accurate” (Cicely), “pie charts are inaccurate” (Buck) “graphs and charts don’t show you everything” (Billy), revealed a glimpse of how students felt about the lesson, and the ideas they picked up on were helpful in the overall analysis. Taken together, these quotes and field observations, helped to form a more complete picture of what participants felt was important during the intervention.

In the second exit slip, about Advanced Charts, including line graphs, after lesson 3, students were asked to “Describe one situation where a line graph is the best way to display data”? In the third exit slip following the fifth intervention lesson students were asked to “Describe at least one way you learned that the creator of a graph or chart could mislead viewers?”. In the fourth, and final, exit slip following the Case Study, the students were asked to recall “the most important idea or fact you learned during the study”. The responses from these three questions were also copied verbatim, with the questions, into a Microsoft (MS) Word document, then entered as a transcript into Delve Tools. Again, the act of combining the responses into a MS Word table changed the feeling of the responses and an overall sense of the participants views became clearer.

In the second exit slip open-ended response, the students were asked to "Describe one situation where a line graph is the best tool to display data"? Again, student responses varied, with six of twelve (50%) of the respondents suggesting that the line graph is best used to show, or track, change over time. Three of the students (25%) reported the best use for a line chart was to show many data points, while two (17%) suggested that showing trends was the best use for a cline chart. One student (8%), Edgar, related that a line chart is best for when "you are trying to tell a story".

In the third open-ended, exit slip question, after intervention lesson four, students were asked to focus on how graphs and charts might be misleading. Jack reported that chart creators "make bars or graphs bigger than they should be to push a narrative", while Claudia stated that "Creators can make charts/graphs favor what they want by changing the appearance to favor what they want people to see". Five of the 13 respondents (38%) reported deceptive practices with the improper height/width of bars in bar charts, while the remaining students (62%) focused on misleading [uses of] pie charts.

In the final open-ended question, after the intervention Case Study, students were asked to consider "the most important idea or fact you learned during the study"? Three of the 15 students (20%) responded with ideas about COVID-19 facts, which the Case Study was based on, although the question was actually about the overall study. Four students (27%) reiterated the idea that charts and graphs may be misleading, and another three students (20%) focused on reading all elements of the charts and graphs carefully before making decisions. One student (7%) reported that using formulas in spreadsheets was the most important lesson, while the final student reported that creating charts/graphs in spreadsheets was the most important idea learned.

The student's responses from the exit slips were also saved together as a single transcript in Delve Tools and analyzed via coding along with the responses from the focus group interview to create an overall scheme of codes, categories, and themes to analyze the complete body of data.

Focus Group Interview Analysis

The focus group was originally scheduled for eight participants in a single group location, but because attendance was restricted after a local COVID-19 quarantine period, the interview was conducted with the researcher and one participant in the classroom, and seven students at home, participating remotely. The interview took place during a regularly scheduled 55-minute classroom period, with non-participants from the class, working on the intervention posttest. The researcher and the in-school participant shared a conference microphone for speaking during the presentation, and watched the interview on a Smartboard, which displayed the images of the other participants. The entirety of the focus group was video recorded using Google Meet after consent was obtained from all the participants.

Two of the participants had arranged earlier to write down their answers as the interview was conducted in lieu of verbally participating in the discussion. Immediately prior to the interview, the questions were shared with all the participants, including the two who were answering in writing. Students were provided a shared Google Document and encouraged to provide written responses, additional thoughts that developed after we moved past each question and new ideas developed during the interview. After the interview was completed, the comments from the shared Google Document were pasted into the transcribed interview. None of the participants had the questions before the

interview, to ensure that at least the live discussion would be spontaneous. During the interview, each student had their own copy of the questions on a shared Google Doc shared via Google Classroom. Participants were able to make comments on their copy of the questions, and each submitted their additional comments after the meeting was concluded. All eight of the participants added at least one written response to add detail or clarification to something they had said onscreen or heard As mentioned earlier, two of the participants submitted responses to each question during the interview in lieu of saying them during the interview. All written comments were copied verbatim to the appropriate place [question] in the video transcription.

After the video was recorded and stored in Google Drive, the researcher watched the completed video and made notes about possible errors that might occur during transcription. The entire video was transcribed using YouTube, and the transcribed file was edited three times by the researcher before coding and analysis began. The first edit was to remove extraneous noises (coughs, throat clearing, “umms”, and other background sounds). The second edit focused on getting transcription errors corrected (names, pronunciations, etc.) and the third edit was to add the written commentary from the participants mentioned above. The written comments were added at the end of the verbal responses for each question.

After participant names were removed, the transcription was shared with one of the eight focus group participants, Tom, to gather feedback and affirmation that the transcript captured the essence of the interviewee responses. The participant reported that in his opinion, the transcript was a good representation of the focus group interview.

Coding

After the data were transcribed, cleaned up, and copied into Delve Tools, a series of coding exercises was completed. As Creswell (2018) explained, "the traditional approach in the social sciences is to allow the codes to emerge during the data analysis" (p. 197). The explanation of the coding process is described below in sections labeled: a) first round coding, b) second round coding, c) third round coding and d) fourth round coding. After the coding was completed, the codes were categorized, and then themes were developed from the codes and categories.

First Round Coding. After the transcripts were loaded into Delve Tools, the transcripts were evaluated using a generic approach (Saldaña, 2016), using descriptive coding on a sentence-by-sentence basis. Even though Saldaña suggested to not use descriptive coding as a default method without further analysis (Saldaña, 2016), it seemed logical based on the variety of questions and responses given by the students. In Vivo coding was added to capture the nuances of the student responses, because they are 'participant inspired' and suggests what the user feels is significant (Saldaña, 2016, p. 107). The essence of each sentence was captured using a descriptive code, which summarized the sentence, such as "Increased Understanding", applied to the sentences "I have developed a stronger understanding of US history by looking at authentic/relevant data" and "I was able to gain a better understanding". The code "Increased Understanding" was also applied to phrases, such as "…helped make the understanding all right" and "…a little bit better than I had in the past." See Figure 4.1 for the Delve Tools association between the code "Increased Understanding" and various text from various student response types.

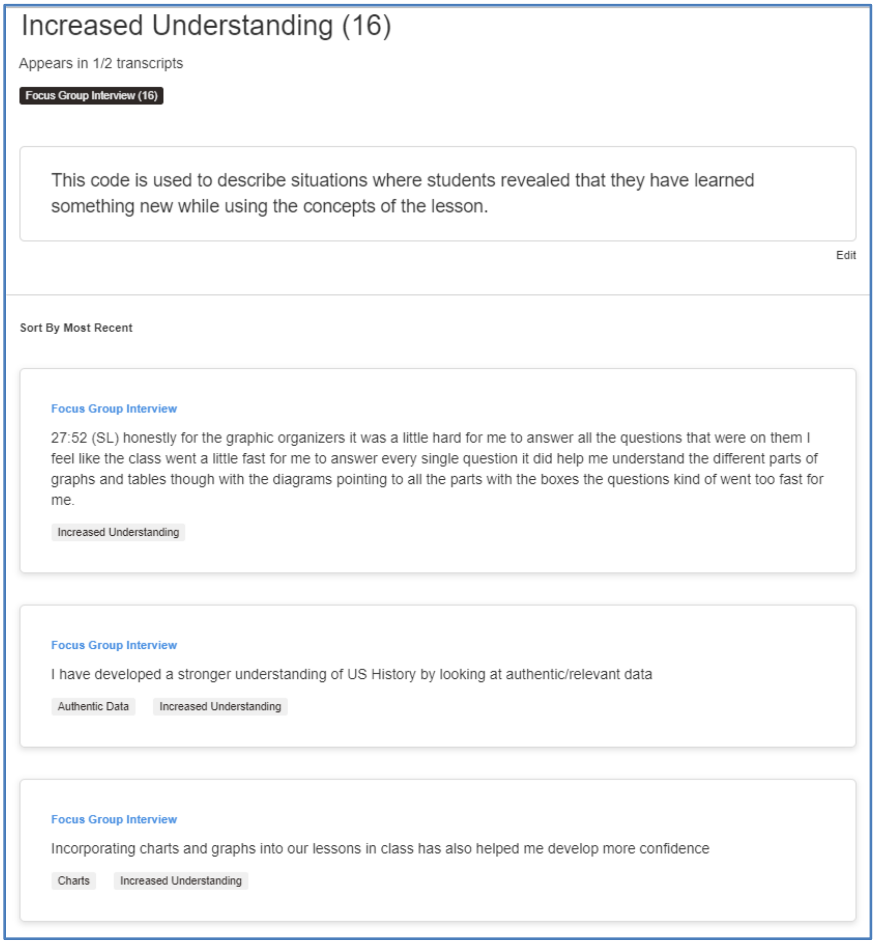

Figure 4.1. Delve Tool Code "Increased Understanding"

Some codes, such as "Higher confidence when explaining concepts" was applied to more complex thoughts, such as the following from Tom, who responded to focus group interview question 8:

> With some confidence definitely because I at least know something, and I may not know like what everyone else was saying super advanced stuff, but I could probably talk for a little while about charts and graphs and what I've learned and how it applies to like history and the world today.

This first round of coding generated 118 separate codes which revealed several important ideas about the interviewee's engagement with the materials presented in the

intervention. An example of the initial code "Learned how to create a spreadsheet" is shown in Figure 4.2. Even though the idea of creating a spreadsheet was a central focus of the intervention, the code was applied only one time to the transcripts.

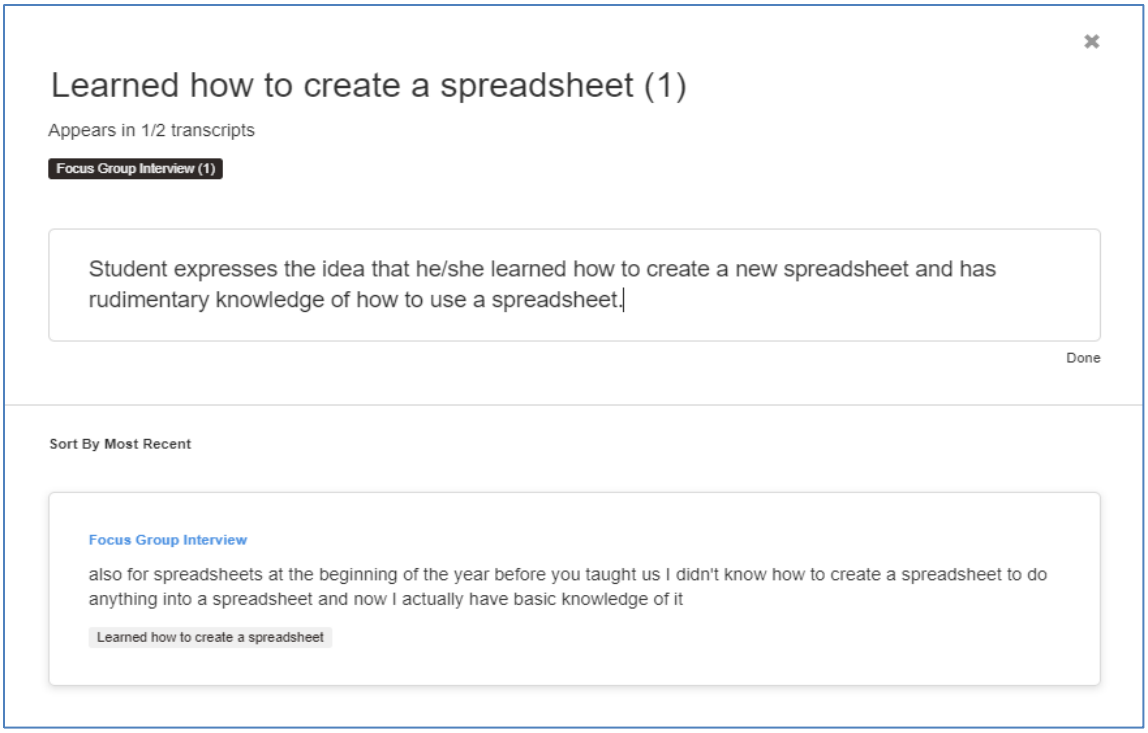

Figure 4.2. Delve Initial Sentence Code with Description

First round coding continued by reviewing the transcripts for In vivo codes which captured specifically worded phrases that supported the Descriptive codes from the first evaluation or added additional meaning to the process. A total of 27 In vivo codes were generated and added to the initial code list in Delve. In vivo codes were created with quotes around the text to distinguish them from the descriptive codes.

Twenty-two of the 27 In vivo codes were applied only one time, while five were applied to multiple responses: "charts are inaccurate" was used 9 times, "graphs are often misleading" [4], "visual learners" [3], "graphs can skew data" [2] and "not great at math' [2]. Example In vivo codes included "I am looking deeper" and "look for the meaning",

which were most likely embedded in lengthier participant responses. Figure 4.3 below shows the In vivo code "look for the meaning" in context with the overall response to question x from the focus group interview. The overall sentence code, applied in the first round was "Increased Understanding", and the In vivo code "look for the meaning" captured a specific intent of the overall meaning of the response. A list of all of the codes is found in Appendix L: First and Second Round Codes.

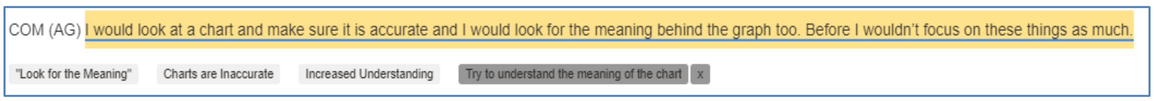

Figure 4.3. Delve Tools Example of In Vivo Coding

Second Round Coding. Both transcripts were reevaluated in the second round of coding by adding additional codes to parts of a sentence or phrase which captured individuals' thoughts in a complex sentence. Structural coding (Saldaña, 2016) was applied to phrases which referenced parts of the research questions, such as "graphic organizers", "spreadsheets" and "authentic data". These codes were useful for determining how many times and when students referred to one of the research question phrases. Some of the codes were similar to the original codes from the first round, but many were new, which expanded the initial codebase to 164 descriptive codes and the 27 In vivo codes, for a total of 191 individual codes. The second-round coding was performed two times, the second time two days after the initial coding to allow time to reflect on the first codes and to review the transcripts for meaning not revealed in the first pass.

Many of the second-round codes were also descriptive, because they were expected (Creswell, 2018) and often subsets of a similar first-round code, to either add meaning or introduce a new concept similar to the first-round code. For instance, the

first-round code "Understanding" was broken down into more specific details in the second round. Second round codes derived from the first-round code "Understanding" were "Trying to understand the meaning of the chart", "Understanding the whole helped understand the parts", "Understanding increased during the intervention" and "Understanding the examples". Other codes were developed as well from "Understanding", such as "Explain Principles" which indicated that students could explain something to others after learning new material, and even "Higher Confidence when explaining principles". Figure 4.4 contains the addition of second-round codes to the original code "Understanding".

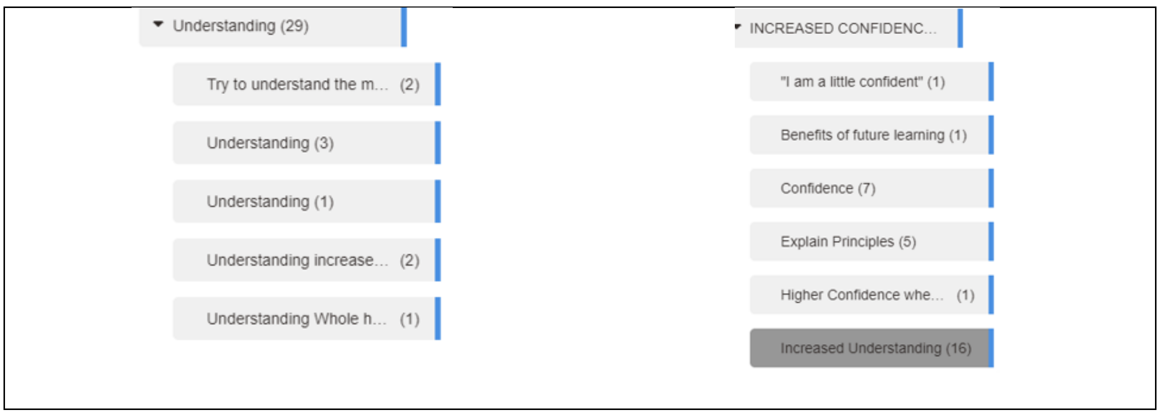

Figure 4.4. Expanding Codes "Understanding" and "Increased Confidence"

However, as Creswell (2018) predicted, some surprising codes developed, which had not been expected. Students had some negative comments about the technology platform we used for the intervention, and some scattered comments about the speed of the instruction, and these unexpected comments were coded and eventually became a third, unexpected theme, largely attributed to the change in technology brought about by the switch to remote learning.

Third Round Coding. Each of the individual codes was written onto an individual 3" x 5" notecards and then sorted into related groups, formed primarily by sheer repetition of concepts from the codes. Eventually, ten groups were created with codes that described a specific aspect of the data. For instance, a group entitled "Charts" was created, containing 40 individual codes related to all aspects of charts: creating charts, understanding charts, realizing that charts are deceptive, knowing when to apply charts, and other chart-related codes. Table 4.8 contains the ten groups of codes and the number of individual codes that were associated with each. The codes in Delve were not reorganized into the ten initial groups.

Table 4.8. *Second round codes assigned to initial groups.*

Group	Number of codes
Charts	40
New Skills	34
Instructional Issues	28
Understanding	27
Benefits	15
Bar/Line Charts	15
Spreadsheets	13
Online Vs Remote	10
Graphic Organizers	6
Math/Quantitative Literacy	5
Authentic Data	4
Case Study	3
Total	191

During the three rounds of coding, descriptive coding, the most commonly applied code was "Increased Understanding" which was applied 31 times, while "Understanding" was applied 29 times. The remainder of the top ten most applied codes were: "Apply Skills [25]," New Skills" [22], "Chart Errors" [20], "Charts are Inaccurate" [15], "Charts" [14], "Authentic Data" [13], "Line Graph Uses" [13] and Positive

Spreadsheet Skills [10]. One hundred six codes were applied only one time during the coding process.

After the ten groups were established, the index cards in each group were laid out and a sub-grouping of the codes was performed. For instance, in the “Chart” group, the individual codes were regrouped into smaller groups, such as “Creating Charts”, “Learning about Charts”, “Misleading Charts”, “Applying Charts to Other Areas” and “Reviewing Underlying Data”. The ten initial groups were divided into 53 smaller, more specific groups. Figure 4.5 below shows the 53 subgroups as initially developed.

Delve Group Coding Version 1 4/22/21 @ 18:12 PM

Charts (40) • Creating Charts. • Learning about Charts. • Misleading Charts. • Applying Charts to other Areas. • Reviewing Underlying Data.	New Skills (31) • Spreadsheets and Formulas. • Charts and Graphs. • Labeling. • Chart requirements. • Data Precision. • Applying Principles.	Instructional Issues (28) • Chromebook Issues • Screen Size. • Paper vs Online Graphic Organizers. • Amount of Content Presented. • Making Notes on Screen.	Understanding (21) 1. Study Enhanced Math/STEM. 2. Created Connections. 3. Applied Learning to Other Subjects. 4. Strengthened Previously Learned Material. 5. Added to Previous Schema.
Benefits (15) • Applied Learning to other Subjects. • Saw need for Future Use. • Applied to Future. • New Ways to Look at Data. • Created New Awareness.	Bar/Line Charts (18) • Creating Charts. • Learning about Charts. • Misleading Charts. • Applying Charts to other Areas. • Reviewing Underlying Data.	Spreadsheets (13) • Creating Formulas. • Math Skill Benefits. • Data Precision. • Creating Charts from Relevant Data.	Online vs. Remote (10) • Chromebook Issues. • Benefits of Graphic Organizers. • Problems with Graphic Organizers. • Communication Issues. • Screen Size Issues.
Graphic Organizers (6) • Paper vs Online. • Too Small Online. • Hard to Add Data. • Used Authentic Data.	Math/QL (5) • Improved Math Awareness. • Added to STEM knowledge. • Boosted Math Confidence.	Authentic Data (4) • Useful. • Made Applying Knowledge Easier. • Tied to Subject. • Used Appropriate History Material for Class.	Case Study (3) • Applied Knowledge to Real-World Situations. • First Time to Notice Real Issues with COVID-19.

Figure 4.5. Original Ten Code Groups Organized into 53 Subgroups.

Categories

The 53 subgroups were distributed into 20 categories, some with similar meaning and applications, yet distinguishable based on context and nuance. For instance, the code “Applying Charts to Other Areas”, originally under the Group “Charts” was a better fit with ideas about learning new skills and/or gaining understanding. Many of the subgroup entries were rearranged until 20 categories emerged. Figure 4.6 shows the final process

from the original ten groups to the three emerging themes. The subgroups were originally color- coded to show their original location and final grouping in categories to aid in the moving of the codes in Delve.

Original Grouping	Original Category Creation	2nd Category Sorting/Editing	Sample Coded Excerpts	Emerging Themes
Charts (40)	Misleading and deceptive charts Creating and labeling charts	Creating and labeling charts Applying Charts Correctly Misleading and deceptive charts Creating spreadsheets Creating and using formulas Enhanced math and stem skills Greater understanding of concepts New knowledge added to schema. Basic Knowledge Acquired. Applying Concepts to Future Learning	Claudia admitted that the lessons helped her in other courses, by stating: Incorporating math and numbers into my humanities classes helps me engage in discussions and make better connections because I can grasp the topics.	Combining multiple tools and methods of instruction helped students gain a deeper understanding of concept and knowledge during the lessons.
New Skills (31)	Applying concepts to future learning			
Understanding (29)	Greater Understanding of Concepts Increased confidence in ability New Knowledge applied to schema. Importance of visual learning			
Instructional Issues (28)	Chromebooks Issues Online Issues	Increased confidence in ability Benefits of authentic data Graphic Organizer Considerations New Skills applied to learning history. Use of a case study. Applying meaning through activity Applying Concepts to Future Learning	Billy: I think the use of authentic data helped because as a student learning about history in this history class if you were to display information about like a completely different topic, I would have not followed at all but since you used the information that we are learning in class from the time periods…	Student perceptions were positive about the effect of learning with authentic, relevant, data and graphic organizers when combined with spreadsheets, charts, and graphs.
Line and Bar Charts (15)	(combine with charts)			
Benefits (15)	Applying meaning through activity			
Spreadsheets (13)	Creating Spreadsheets Creating and Using Formulas			
Online Issues (6)	Combine with Instructional Issues	Importance of visual learning Chromebooks Issues Online Issues Instructional Issues	Samantha: Chromebooks "are very slow, they glitch a lot, so it's hard to have multiple tabs open or be in Google Meet and be doing something else on the same device".	Student's ability to learn was impeded by the abrupt change to the learning environment and limitations of the online setting.
Graphic Organizers (6)	Graphic Organizer Issues			
Math/QL/ STEM (5)	Enhanced Math and Stem Skills			
Authentic Data (4)	Benefits of Authentic Data New Skills applied to learning History			
Case Study Comments (3)	Use of a Case Study			

Figure 4.6. The Transformation of Codes from Grouping to Categories to Themes.

As an example of this process, the six subgroups under the "Chart" group were represented in two categories in the original categorization round: "Misleading and deceptive charts" and "Creating and labeling charts". Those two categories were regrouped with eight other categories as the theme "Combining multiple tools and methods of instruction helped students gain a deeper understanding of concepts and knowledge during the lessons." emerged.

Ultimately, 20 categories were created in Delve using all capital letters to identify them, such as "APPLYING CHARTS CORRECTLY" and "ONLINE ISSUES". Figure 4.7 shows the list of the final 20 categories in Delve.

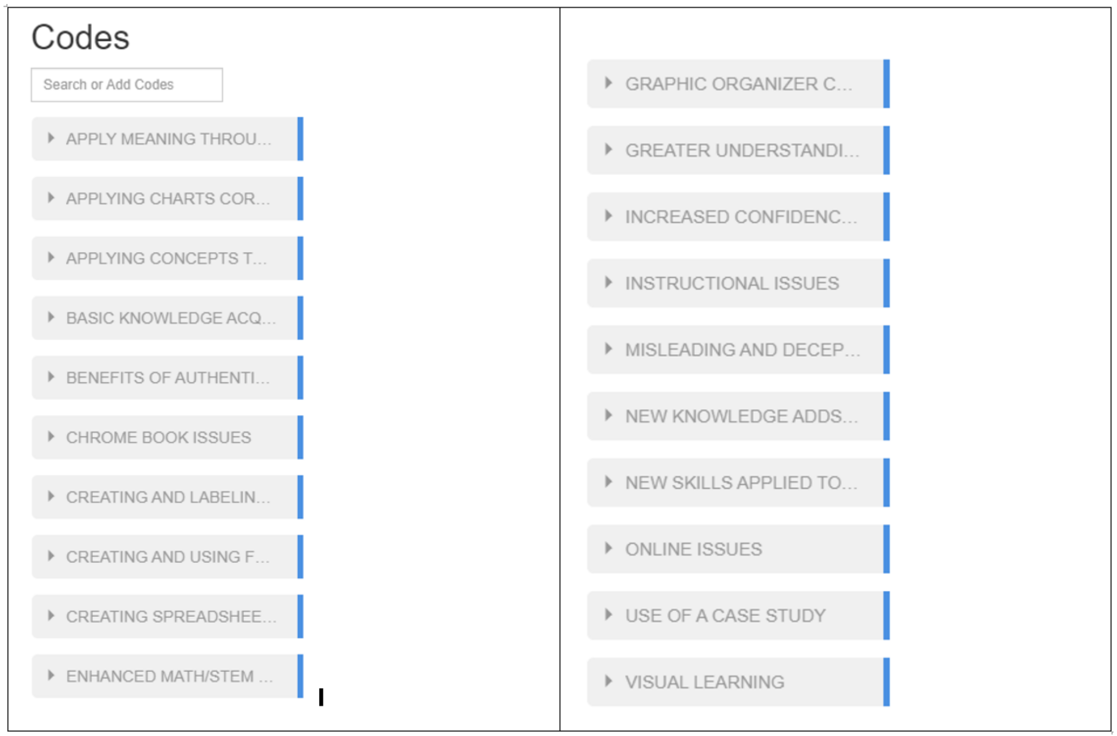

Figure 4.7. Twenty Final Activity Categories in Delve

Figure 4.8 shows an example of the final arrangement of categories, subcategories, and individual codes in Delve Tools for the category "GRAPHIC ORGANIZERS", with two subcategories, "Benefit of Graphic Organizers" and "Issues with Graphic Organizers". Individual codes were reorganized from their original positions to the appropriate categories/subcategories.

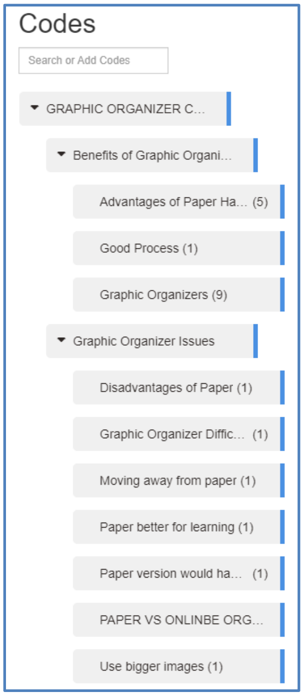

Figure 4.8. GRAPHIC ORGANIZER Category with Subcategories and Codes.

The 20 final categories are described below, grouped together under their corresponding themes: (a) combining multiple tools and methods of instruction helped students gain a deeper understanding of concepts and knowledge during the lessons, (b) student perceptions were positive about the effect of learning with authentic, relevant, data and graphic organizers when combined with spreadsheets, charts, and graphs, and c) student's ability to learn was impeded by the abrupt change to the learning environment and limitations of the online setting. Each description began with the category name, followed by an explanation of its development during the coding process.

Combining Multiple Tools and Methods of Instruction Helped Students Gain a Deeper Understanding of Concepts and Knowledge During the Lessons.

The categories in this theme are based on the findings that students learned new skills during the intervention that deepened their understanding of ideas they had previously learned but may not have connected to the concepts of using

spreadsheets, authentic data, and graphic organizers. The ten categories that were used to develop the first theme, are described below. The categories progress from the broadly applied code, “Basic Knowledge Acquired”, to the specific “Creating and Labeling Charts” to the higher-order thinking involved in “New Knowledge Added to Schema”.

Basic Knowledge Acquired. These codes applied to knowledge, skills, or principles that were learned for the first time, including knowledge of spreadsheets, charts, math concepts, or historical facts. When Billy confided “before you taught us, I didn't know how to create a spreadsheet to do anything into a spreadsheet and now I actually have basic knowledge of it”, the sentiment was coded as “New Skills”, but not initially in this category. When discussing his learning of spreadsheet functions, Billy also added “I have the general and basic knowledge of all these all this stuff” which indicated that he had learned some fundamental information, but not enough to be confident in its use.

Regarding the applications of principles learned, the code “Application of Principles” was given to statements like Claudia’s when she mentioned that her understanding was increased when the “the concepts that we were learning about applied to what we were learning”. These comments were generic in nature and did not include specific mention of the tools used for the intervention.

Creating spreadsheets. This category was created from ten codes, applied 35 times in the participant responses were specifically about the rudimentary skills involved in the creation of spreadsheets. The codes described the actual entry of data, positive feedback on the spreadsheet lesson, ability to strengthen math concepts, and the

identification of hidden sheets and data. The code, "Positive Spreadsheet Experience" was applied 11 times, to student feedback such as "it's easy to make the actual graphs in a Google Sheet" and "important lessons I learned about numbers". The basic code "Spreadsheet" was applied 15 times to generic statements about the spreadsheets. such as Jill's "we used a lot of different kinds of numbers" and her "I also now know how to put those numbers into charts".

This category was important because it was essential that participants learned about the relationship between the raw, underlying data and the charts and graphs that were produced from them. Tom, while talking about this topic, revealed that he now looked at "the meaning behind the creation of the data, as opposed to just looking at the numbers".

Creating and using formulas. Codes in this category extended the creating spreadsheets category and focused on the use of proper formulas to manipulate data, as well as using the copy functions, relative and absolute reference formats, and sorting techniques. Using the spreadsheet as an analytical tool was part of the intervention presentation, and most of the students walked away from the intervention with increased confidence and ability in the use of formulas to manipulate data.

These four codes ranged from the importance of creating formulas to the increased ability in math skills gained by using them. Jill admitted that "I know how to use all the formulas now which helps me put things into the spreadsheet easier", which was coded as "Formulas Improved Math Skills". Sissy wrote in response to the question about the most important idea learned during the intervention that "I feel like the most

important thing I learned during the study was how to use formulas in spreadsheets, it is a much more efficient way to add numbers".

Creating and labeling charts. A significant portion of the intervention lessons was about participant engagement with charts and graphs. This category was created from ten coded entries that suggested that students either learned how to create and label charts "Creating Meaningful Charts", the importance of the labeling "Charts Provided New Information", or the value of understanding the labels and how they helped interpret the data. Samantha commented during the focus group interview, that "I know when I look at labels like that that I can understand that like what the data actually means", which was coded "Look at Labels". Jill stated on one of the exit slips that "the most important thing I learned was how to make graphs and charts on spreadsheets".

One of the main tenets of the intervention lessons was that you must know how to create a chart before you can analyze it completely. In addition, the students learned about the value of correctly labeling each graph or chart to aid in analysis. The students agreed and Tom mused "I think that in history knowing how to read and understand bars and charts is important because you can see over time how things are changing". This category, with codes such as "Look at Labels" was applied to Samantha's observation "So now I know when I look at labels like that that I can understand that like what the data actually means and the significance of it".

Applying Charts Correctly. In this category are codes that were applied to choosing the right chart for the numeric task at hand. Students were able to differentiate between the types of charts and graphs and determine which graph correctly displayed the data. During the intervention, the graphic organizers highlighted rules for various

graphs and charts. The 20 codes in this category were about all kinds of charts and graphs, but ten of them were specifically about line charts.

Under the category “Pie Charts Important Lessons”, Billy stated that “pie charts should only have seven or eight slices so for things smaller than like one percent the pie chart doesn't really show that and now I have to think about is this a reliable source to use or not”. Jack recognized that “some charts are better than others in certain situations” and Sissy echoed the sentiment by stating “I learned when to use certain graphs like a pie chart or bar graph for example”.

Following the lesson on the use of line charts, participants responded to the question about when to use line charts by responding with various answers. Buck suggested that line charts were best “When you're trying to show trends’, Edgar suggested line charts are best “When you're trying to show trends” and Mary remarked “when there are a lot of data points”. Some participants gave a twist on similar responses, when Christian stated, “When tracking changes over short periods of time”, but Tom countered with “When tracking changes over short or long periods of time”.

Misleading and deceptive charts. This category was one of the largest categories in terms of underlying codes. Comments used in the creation of these 22 codes were offered as early as the first lesson, when participants picked up on the idea that many charts and graphs are deceptive. Coding was applied to student awareness that graphs and charts could be either intentionally or unintentionally misleading and that each type of chart/graph had specific components which helped display and understand the underlying data. Students were also aware of chart limitations and the importance of component use, and how they could be used to mislead viewers.

The most common codes in this category were "Chart Errors", applied 20 times, and "Charts are Inaccurate", applied 15 times during the first round of coding. Student comments ranged from Sissy's "I also know that just because something is in a chart does not mean that the information in it is accurate" and "I also know that just because something is in a chart does not mean that the information in it is accurate" to Cicely's "Not all charts are telling the 100% truth & before I would just assume that everything it said to me in the chart was true and completely accurate".

Billy examined errors in pie charts by disclosing:

> because ever since your class I learned that pie charts really only show one thing whether it's like a percentage of something or an exact number but the total number the pie chart really doesn't show that, and you said that pie charts should only have seven or eight slices, so for things smaller than one percent the pie chart doesn't really show that and now I have to think about is this a reliable source to use or not.

This statement is a good example of student application of knowledge from the graphic organizers and instruction that discussed the limitations of pie charts. Claudia used the same analysis to discuss bar charts, where only the height of the bars matters.

> Something I'd say that I'd look at differently now is the one lesson with the advertising and there was one example where they showed soda bottles and the diagram showed Coca-Cola bottle being so much larger than the Sprite bottle, but in reality, it wasn't really that much larger [taller] but the

graph kind of made it appear a certain way so you would believe something that may not actually be true if you look at the actual data.

Claudia also realized that graph makers can deliberately mislead by making "charts/graphs favor what they want by changing the appearance to favor what they want people to see". Tom agreed by stating "In a pie chart, some chart creators will make all the slices the same size, even though they hold different values". Jill summarized the entire analysis of deception in charts and graphs by stating "I can also figure out when charts aren't really accurate and when they are estimating".

Enhanced math and stem skills. Artifacts codified in this category of five codes, and one subcategory, "STEM", were added to comments when participants specifically mentioned that the spreadsheet and chart activities either helped or strengthened techniques, they had learned in STEM-based activities or courses. Sissy acknowledged that she was not great at math, but "when you had the codes [formulas] and they simplified the math on the spreadsheet I feel like that helped me personally".

Claudia admitted that the lessons helped her in other courses, by stating:

Incorporating math and numbers into my humanities classes helps me engage in discussions and make better connections because I am able to grasp the topics, I learn about in my STEM classes more naturally. Personally, I learn a lot more from looking at a set of data or a graph rather than reading a paragraph.

The code "Quantitative Literacy" was applied to seven comments which discussed numeric precision. Although not a point of emphasis during this research, numeric precision is a key component of QL learning. Jill stated that the

spreadsheet helped her with numeric precision with “I also learned how to put zeros on decimals and how to add dollar signs” and Tom acknowledged various numeric formats by claiming for “salary you had to do dollars with two decimals to represent currency and then with another number you just do a normal number and then for the rate you would do a decimal”.

Greater understanding of concepts. These eight codes were applied to 40 comments, more frequently than any others to text, phrases, and sentences that indicated that participants gained increased understanding about an aspect of the intervention or created a connection to previously learned material.

For “Understanding”, participants claimed increased understanding of several concepts. Samantha revealed that “I know when I look at labels like that that I can understand that like what the data actually means and the significance of it”. Tom added, “I was going to say now I would look for the meaning of what the graph is trying to tell me, and …the meaning behind the creation”. Tom also recalled that “I can use it like information that I learned about charts and graphs and when I am confronted with a new one, I’ll be able to apply that knowledge a little bit better than I have been in the past”.

Samantha revealed that “I can understand that like what the data actually means and the significance of it”, while Claudia revealed, “I was a little bit worried on like how I would do but adding numbers into the equation really helped me understand the concepts that we were learning”.

New knowledge adds to schema. This category was based on the idea that new learning is involved with schema development, and even though students are not cognitively aware of the theory, their comments suggested that their new knowledge was

being added to what they already know, and their learning increased. When student comments indicated higher-order learning or the fact that it helped them increase their learning, these comments and thoughts were coded as "New knowledge adds to schema".

Jill stated in response to a question about using charts and graphs that "Yes, I think I can understand them a lot more easily and when I am presented with a new one, I will be able to evaluate it". Jill's comment suggested that the learning was being stored and that she would be able to apply the new concept to a new problem at an unspecified future time. Claudia also added, "Incorporating math and numbers into my humanities classes helps me engage in discussions and make better connections because I am able to grasp the topics".

Applying Concepts to Future Learning. These nine codes were assigned specifically to comments and responses by students discussing the long-range use of the new concepts learned during the intervention. Four of these codes were created as In vivo codes, based on participant responses, such as making "better connections", "I am looking deeper", "look for the meaning" and "put some reasoning".

Claudia remarked that "incorporating math and numbers into my humanities classes helps me engage in discussions and make 'better connections' because I am able to grasp the topics". Billy exclaimed that he was looking for the "meaning behind the creation of this as opposed to just looking at the numbers themselves, and 'I am looking deeper' into…the meaning".

The code "Assist career" was applied eight times, including "definitely help in jobs" (Billy), "helpful with future jobs" (Jill), "definitely going to help me

throughout life no matter what I do" (Tom), and "this will be helpful with everyday life and future jobs" (Jill).

Tom also suggested that the learning was applicable to unknown, future events by suggesting "I am sure one day I'll be confronted with a new type of chart or graph but using the skills that you've taught like the class I think that I'll be able to evaluate it, so I think right now I can evaluate about 90 or 95 [percent] of graphs and charts".

According to Mayer (2014), when students are using multiple modes of learning they are actively processing the new information, which in turn triggers three sub-processes: selecting, organizing, and integrating. The cognitive action of arranging all of the new data together strengthens learning through semantic encoding, or the creation of a new or modified mental structure for the newly acquired knowledge (McCrudden et al., 2009)

Student Perceptions were Positive about the Effect of Learning with Authentic, Relevant Data and Graphic Organizers when Combined with Spreadsheets, Charts, and Graphs.

The seven categories in this second theme are focused more on the benefits of the combination of learning tools used in the intervention, consisting of spreadsheets, charts and graphs, authentic data, and graphic organizers. This theme emerged as students validated the idea that the authentic data collections, such as analyzing the actual Census Bureau charts from the time frame we were studying, helped in learning about population changes and charting together. Students reported that together these activities

strengthened their learning of both concepts and increased their ability to explaining the concepts to someone else.

Increased confidence in ability. The idea of increased confidence seemed to go along consistently with the idea of greater understanding and was composed of eight separate codes ranging from “a little confident” to “confident” (seven comments) to “higher confident. These codes emerged as students expressed the idea that the intervention had increased their understanding of a concept, so they were able to present it to others.

Students such as Samantha claimed, “I think that I could explain it [overall concept] to definitely another student or a co-worker” indicating that she was confident in explaining what she had recently learned. Cicely offered “I definitely have a lot more confidence saying that I could explain it to somebody else, but before I don't think I could explain it all at all but now I am a little confident to tell them what happened”.

These comments suggest that participants did learn enough about the intervention concepts that they could explain them to their peers or other students. Under the code “Explain the principles” Jill told the group that “I believe I could with some confidence but more about the general topics rather than the advanced topics that go more into depth”.

Benefits of authentic data. When students ascribed meaning to the use of authentic data, codes were created to capture that sentiment. Five codes were applied to 38 comments to analyze this idea. This feedback was important because the intervention was specifically looking to find the impact of using authentic data on participant’s engagement.

Billy gave a lengthy response to the question about the impact of using authentic data when he said:

> I think the use of authentic data definitely helped because as a student learning about history in this history class if you were to display information about like a completely different topic, I would have not followed at all but since you used the information that we're learning in class from the time periods that we're learning it from it definitely helped make the understanding all right.

Claudia developed the idea even more completely by adding:

> For me, I have developed a stronger understanding of US History by looking at authentic/relevant data and a stronger interest in the subject than I started the school year out with because I was able to learn some information in a way that got me more engaged in the subject.

Claudia also suggested that working with meaningful numbers helped increase understanding because "adding numbers into the equation really helped me understand the concepts that we were learning about especially when we applied it to what we were learning".

Graphic Organizer Considerations. At first every comment about graphic organizers was coded as "Graphic Organizer", to allow grouping of the comments about the organizers to naturally flow together. Later, the category was divided into two subsections: "Benefits of Graphic Organizers" and "Graphic Organizer Issues". There are three codes under "Benefits of Graphic Organizers, and five under "Graphic Organizer Issues". Because the graphic organizer was fundamental to the analysis of the

action research questions, the change in the format of the lessons, introduced unknown factors in the use of the organizers.

Billy noted that “I definitely learned a lot through these graphic organizers and these charts and everything”, but on a less positive note indicated that:

> When I was doing the online graphic organizer, I would always have to zoom into the slide so that I can input the answers, but that would always cause problems because then my computer would act weird, and it would be slow so when that one time that he sent home the graphic organization and that was really helpful.

Billy echoed a concern from the participants that the graphic organizers were very small and unwieldy on the Chromebooks and because of that, students took extra time to zoom in and view them, and also had to zoom in to take notes and fill in the answers.

Samantha indicated that the use of the graphic organizers had positives and negatives, coded under “Graphic Organizers”:

> Honestly, for the graphic organizers, it was a little hard for me to answer all the questions that were on them, [because] I feel like the class went a little fast for me to answer every single question. It did help me understand the different parts of graphs and tables though with the diagrams pointing to all the parts with the boxes, but the questions kind of went too fast for me.

Tom also agreed that the graphic organizers were useful, but also somewhat limiting, by stating that “I agree I wasn't able to everything, but I was able to get like

certain areas of graphs and charts and point out like what's one, so I was able to get some things organized on the page but not everything".

Jill claimed that the graphic organizers "helped me understand parts of the graphs like what each part of a spreadsheet does and represents", while Cicely added, "It helped me understand parts of the graphs like what each part of a spreadsheet does and represents".

Under the code "Advantages of a paper organizer", Tom claimed that "actually learning the material would have been easier on paper", and Billy agreed, saying "I feel like it would help me absorb like the material better if I was writing it on paper", but under the code "Disadvantages of paper", Tom suggested that "not everything is on paper anymore" and we have to adapt to the current technology.

New skills applied to learning history. This was one of the smaller categories with only six codes, applied to five comments, except for the "Learning new skills" code which was used 22 times. In this category, data supported the idea that theses intervention skills and tools supported the learning of history.

Tom appreciated the use of maps and charts to examine history and noted that "I think that in history knowing how to read and understand bars and charts is important because you can see over time how things are changing, and especially with the maps…looking at the ancestry of the United States". Billy added that "I think that in history numbers are really important because for populations if it means it's all numbers so if you want to see how a population increase over time". Cicely agreed with the comment about "charts and graphs and what I've learned and how it applies to like history and the world today".

Use of a case study. The final intervention lesson was a small group activity, which created teams of four to examine all of the skills and concepts learned in the intervention to a case study about the Corona Virus in NJ. Participants and non-participants were mixed in groups, and each group submitted a completed copy of the answers to the Case Study Questions. Students responded to open-ended questions on the exit slip at the end of the study, and their comments formed the basis for most of this category and its codes. The category contained three codes, "Corona Virus information", "COVID-19 is dangerous in NJ" and "Diabetes worsens COVID-19".

The case study was planned to assess the student's ability to transfer the skills learned during the intervention to a current, real-world set of numbers, charts and graphs, and other QL issues. Their comments about the Case Study in the focus group and the Case Study exit slip are included here. Billy observed correctly "that Northern New Jersey is very dangerous with this virus", and Jack concluded that "Coronavirus is a fast-growing and spreading disease and it's blowing by every other disease on graphs when it comes to cases and deaths".

Applying meaning through activity. When students indicated that one learning activity led to improvement in another, that data were coded into one of the five codes used in this category. The most applied code in the category was "Applied skills" which was used 25 times in Delve Tools. Jill explained that one of the best ways to apply skills is "to see the increase or decrease of numbers over time and this was an easy way to understand" the data and apply meaning. Jill was referring to a spreadsheet activity where US population change was viewed and charted over time, which made the numbers more meaningful to the lesson we were addressing.

Claudia, a self-proclaimed STEM student, noted that “just taking this information into math or science class and looking at the way that data is displayed I’ll be able to understand it a lot more and I’ll be able to kind of put some reasoning behind my answers” which suggests that she is considering the transfer of skills from one discipline to another. Billy stated that it would be easy to apply skills learned during the intervention to everyday activities, such as “looking at a newspaper or an article online and it could display a graph, or a chart and you would understand”.

Applying Concepts to Future Learning. This category was used in two themes because it applied to different meanings. In the first theme, this category applied to students using concepts and skills they learned to their current history class and other high school courses. For the second theme, the codes applied to future learning, daily life, college experiences, and unknown future activities.

Tom recognized the broad application of the new skills when he said, “this will definitely help me the most in what I choose to do for my career”, and Billy concurred with “I think it would definitely help in jobs but also in everyday life”. Jill echoed both their sentiments by saying, “I think this will be helpful with everyday life and future jobs”.

This second theme emerged from participant discussion about the importance of using authentic data and its increase in learning both the historical material, and new ways to process information together. Students were generally positive about the new skills they learned using spreadsheets, and also positive about the use of the graphic organizers when in class or using paper copies of the organizers, which were easier to read than the same organizers on a small device screen.

Student's Ability to Learn was Impeded by the Abrupt Change to the Learning Environment and Limitations of the Online Setting.

This third theme emerged as students responded to the focus group questionnaire about issues they encountered during the online portion of the intervention. Had the intervention been conducted in person as planned, with all participants in the classroom, these categories and themes may not have emerged. Most of the codes in this category are about the impact of the technology and the learning environment affected learning and student engagement, affecting both research questions.

Issues presented during online learning. Many of the student comments dealt with physical issues that affected the outcomes of the intervention lessons, and potentially took away some of the intended focus on specific tools and concepts. For instance, Samantha commented that "I agree that being in person would help and working on paper I feel like that be easier and better". Many of the students felt that using a Chromebook, with a small screen at home was not as productive as being in class and participating with a Smartboard and better visual media. In response to another question, Samantha commented that she preferred to be in person because "you do more to pay attention and ask questions. I feel like I would have probably gotten a little bit more out of it in person because I would have been completely involved", and Tom offered:

> I think being in class is better. I think if we take online out of it, and it was all on paper, I think that for me personally, it would have been easier to learn the material…I know we would have to use computers and technology to do spreadsheets in the charts but actually learning the material would have been easier on paper.

Importance of visual learning. The In vivo code "Visual Learner" was applied to three students' focus group responses, as they explained the value of seeing the charts and graphs and using the organizers. Jill explained that "It helped me visually see what we were learning. I think it's important to see the increase or decrease of numbers over time and this was an easy way to understand". Cicely added that "I liked having the visuals to refer to". Tom emphasized that "I am a visual learner so being able to see it on a pie chart or a bar graph would really benefit my learning experience". Referring to the use of authentic data, Emily added that "Visually, it helped me understand what exactly the data were", explaining that the charts of the data we used to support the lesson increased her learning of the material.

Chromebook Issues. As indicated throughout the discussion, when the intervention was physically switched to fully online activity, several Chromebook issues emerged as indicated by student comments in class and in the focus group. The Chromebooks lagged significantly when using wi-fi, according to Samantha's comment that the Chromebooks "are very slow, they glitch a lot, so it's hard to have multiple tabs open or be in Google Meet and be doing something else on the same device. [Using] Google Meet really slows down the Chromebooks".

Billy remarked on the Chromebook limitations when he said:

> when I was doing the online graphic organizer, I would always have to zoom into the slide so that I can input the answers, but that would always cause problems because then my computer would act weird, and it would be slow.

ET also remarked about Chromebook limitations when she said, “since I had the Google Meet open as well as the graphic organizers it was hard to see everything on the screen”.

Online Issues. These codes captured student frustration with working at home and the comments of students who preferred to work at home. Tom observed that he preferred working in class by stating “I think being in class is better I think if we take online out of it and it was all like paperwork I think it would have been easier to learn the material if it was on paper”, while Samantha responded with ” I think it helped when we were at home” but “in terms of being in person or at home I’d prefer to be in person.”

Instructional Issues. The 11 codes in this category were drawn from participant’s comments about the speed of instruction, the complexity of graphic organizers, and other instructional issues that may have hindered or impeded learning. The codes ranged from the In vivo code “Went too fast for me” to “Pace was fast” to “Pace was a little fast”. Samantha felt rushed for time at least once, and she noted “honestly for the graphic organizers it was a little hard for me to answer all the questions that were on them I feel like the class went a little fast for me to answer every single question”.

With the addition of the online-only format, it was difficult to tell if students could hear the instruction, work as quickly writing down information in the organizers, and asking and discussing questions. Samantha discussed multiple situations with this comment that “I feel like if that [instruction] was slowed down, the pictures were bigger and maybe if the questions were like more directly addressed in class that would help”.

The final theme emerged unexpectedly from the initial close reading of the focus group interview and subsequent coding of the qualitative data. The initial intervention

lessons occurred in the classroom with a large format Smartboard and paper copies of the graphic organizers. Students were in fact using the printed graphic organizers because it reduced the amount of processing time for their Chromebooks and were easier to read and fill in than the onscreen version of the organizer. In fact, the online lessons were less effective, and did not cover all the intended material, because of the increased processing time required by the school-issued Chromebooks.

Themes

After the original codes had been grouped and categorized, three themes emerged from the data. Although the codes provided the primary source for the development of the themes, the multiple readings of the transcripts, the number of student quotes, reflection on field notes and observations, and the evidence from the quantitative data all provided input for the emerging themes. Student quotes alone did not provide the overall evidence for the themes, but they were considered in the final process of development (Blazely, 2009). Student quotes provided invaluable meaning and awareness of the lessons learned during the intervention. The inductive analysis of the data from the questions in the exit slips and during the focus group interview led to three overarching ideas, or themes: a) "Combining multiple tools and methods of instruction helped students gain a deeper understanding of concepts and knowledge during the lessons.", b) "Student perceptions were positive about the effect of learning with authentic, relevant, data and graphic organizers when combined with spreadsheets, charts, and graphs", and c) "Student's ability to learn was impeded by the abrupt change to the learning environment and limitations of the online setting". The first two themes were in line with the goals of both research questions, which were to examine the benefits to the

participants of the use of spreadsheets, graphic organizers, and authentic data. The third theme, in line with Research Question 2 is important because it demonstrates the effect on learning that the forced change to an online format had during the intervention. Table 4.9 displays the three themes and final categories that were used to develop them.

The categories which came together to form the three themes were discussed in the previous section. The themes were derived by examining the codes and categories, but also by reflecting on the research by talking to participants, students in other classes, and the faculty about our shared online experiences and how they were affected n by online instruction. Many of the student comments and the exit slips were repeated in class after the intervention and data collection was complete.

Table 4.9. Emerging Themes, Underlying Categories and Supporting Evidence

Theme	Supporting Categories	Supporting Evidence
Combining multiple tools and methods of instruction helped students gain a deeper understanding of concepts and knowledge during the lessons.	Creating and labeling charts. Applying Charts Correctly. Misleading and deceptive charts. Creating Spreadsheets. Creating and using formulas. Enhanced math and stem skills. Greater understanding of concepts. New knowledge added to schema. Basic Knowledge Acquired. Applying Concepts to Future Learning.	Student feedback Cicely: "charts and graphs and what I've learned and how it applies to like history and the world today". Billy: "I think this will be helpful with everyday life and future jobs". Claudia: "developed a stronger understanding of US History by looking at authentic/relevant data and a stronger interest in the subject …got me more engaged in the subject."
Student perceptions were positive about the effect of learning with authentic, relevant, data and graphic organizers when combined with	Increased confidence in ability. Benefits of authentic data. Graphic Organizer Considerations. New Skills applied to learning history. Use of a case study.	Student feedback Claudia: "able to make 'better connections' because I am able to grasp the topics". Cicely: "using spreadsheets, formulas, "charts and graphs and what I've learned and how

Theme	Supporting Categories	Supporting Evidence
spreadsheets, charts, and graphs.	Applying meaning through activity. Applying Concepts to Future Learning.	it applies to like history and the world today ".
Student's ability to learn was impeded by the abrupt change to the learning environment and limitations of the online setting.	Importance of visual learning Chromebook Issues Online Issues Instructional Issues	Student feedback Tom: "I think being in class is better" Samantha: Chromebooks "are very slow, they glitch a lot, so it's hard to have multiple tabs open or be in Google Meet and be doing something else on the same device".

Combining Multiple Tools and Methods of Instruction Helped Students Gain a Deeper Understanding of Concepts and Knowledge During the Lessons.

This theme emerged as students provided feedback on the ideas of not only learning new skills, such as creating and using spreadsheets and formulas, but how that learning led to new concepts upon application. Many participants reported that they never realized that charts and graphs could be deceptive and that understanding the underlying data were crucial to interpreting charts and graphs. One of the students, Jill, commented that "I would look at a chart and make sure it is accurate and I would look for the meaning behind the graph too. Before I wouldn't focus on these things as much", and that "I can now look at different kinds of charts and figure out what they are showing much better. I can understand them much better. I can also figure out when charts aren't really accurate and when they are estimating".

Some of the students recognized that there were yet unknown skills they could apply the new concepts to, as indicated by Tom in the statement "I am sure there's still some out there that are like really confusing", referring to graphs and charts we did not

cover in the lessons. Samantha remarked that “I can use it like information that I learned about charts and graphs and when I am confronted with a new one, I’ll be able to apply that knowledge a little bit better than I have been in the past.” Sissy commented that “I feel like I can understand how to read a chart or graph like a line graph or bar chart for example and accurately process the information on it.”

Referring to the use of authentic data (graphs and charts specifically related to the subject we were learning, was also beneficial to the participants. Participant Billy responded to focus group question 11 about the use of authentic data by stating:

> I think the use of authentic data helped because as a student learning about history in this history class if you were to display information about like a completely different topic, I would have not followed at all but since you used the information that we're learning in class from the time periods that we're learning it from it definitely helped make the understanding all right.

Student Perceptions were Positive About the Effect of Learning with Authentic, Relevant Data and Graphic Organizers when Combined with Spreadsheets, Charts, and Graphs.

This theme emerged from the comments by students that the spreadsheets, graphic organizers, and use of authentic data together helped them learn better. Samantha commented that “I agree I felt like learning how to do the formulas and the codes into themselves I feel like that helped me it was of significance because now I know how to do that and when I need to use spreadsheets in the future, I already have all the base knowledge”.

It was intended that the students use all three tools – spreadsheets, graphic organizers, and authentic data – in the learning activities during the intervention. It was not mentioned to the students that one of the goals of teaching QL is to have the concepts applied to multiple areas of learning and practice. On their own, students commented about the applicability of what they learned to other courses, STEM activities, work, life, and career.

Student's Ability to Learn was Impeded by the Abrupt Change to the Learning Environment and Limitations of the Online Setting.

The conduct of the research changed dramatically when our school went to a hybrid schedule, with some students in school and others at home, then fully remote for periods of time. All the graphic organizers had been created for use in both paper and online forms so that students could pick the model that best suited them. The format and usability of the graphic organizers were not the topic under study, but the usability certainly played a factor when students were not able to open, view an edit them while at home on school-issued Chromebooks. In fact, based on the home situation of each participant, the combination of computer devices, wi-fi accessibility and reliability, and screen resolution could not be evaluated, so in essence, each participant had a slightly different experience.

According to Januszewski and Molenda (2008), Student Academic Learning is affected by a considerable number of factors, but primarily by Instruction, Effort, and Aptitude. Aside from these three main components, the Classroom and School Environment also affect student learning, along with a host of internal and external pressures, including motivation, peer pressure, personality, time on task and teacher

characteristics. Figure 4.9 below captures the model by Molenda (2005) describing the relationship. Moving between three instructional formats (in school, hybrid, and fully remote) altered many of the variables simultaneously, making the measuring of student engagement difficult, while forcing the research to consider the questions about online instruction. In the light of the circular nature of action research, it was imperative to consider these changes as an important outcome of the research.

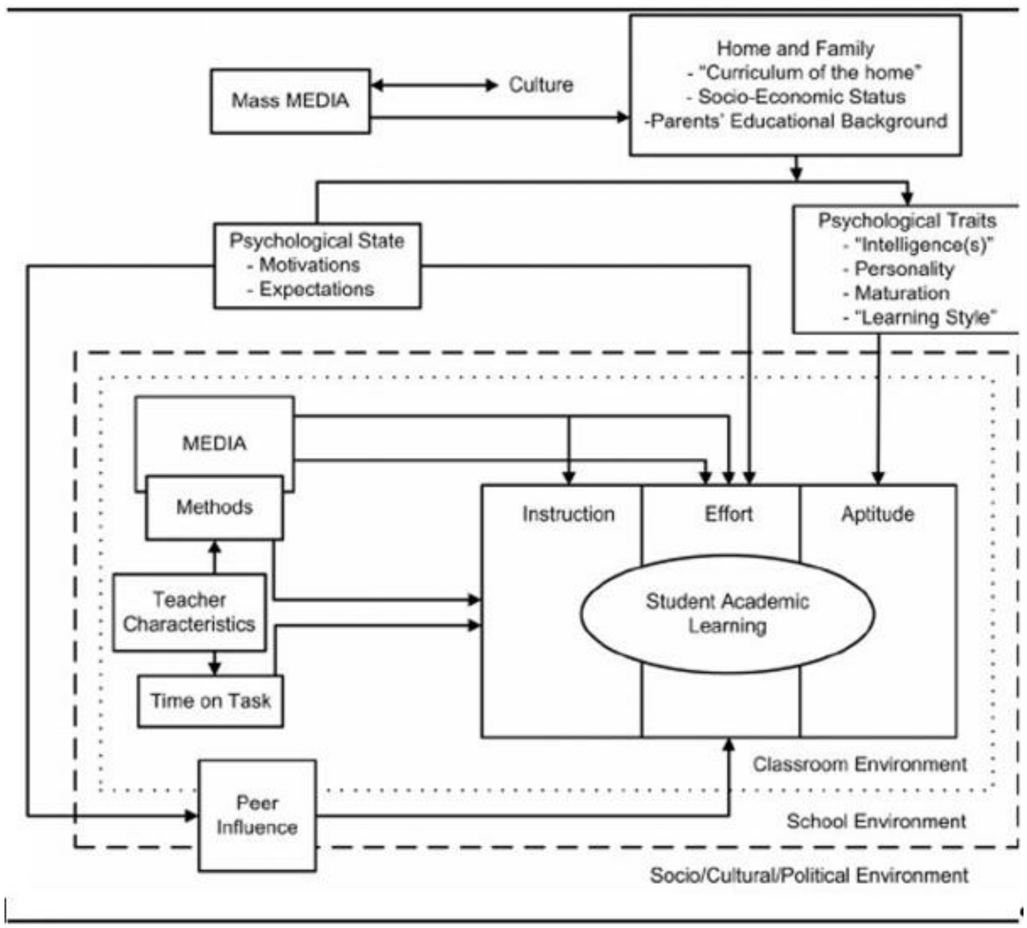

Figure 4.9. Student Academic Learning. Used with permission (Molenda, 2008).

CHAPTER 5

DISCUSSION, IMPLICATIONS, AND LIMITATIONS

The purpose of this action research was to investigate if the use of spreadsheets, authentic data, and analysis of charts and graphs had an impact on the quantitative literacy skills of 11^{th} grade history students at Suburban High School, and to determine what the student's perceptions were about the instruction. This chapter presents the findings and how they relate to the research questions and the literature. In addition, this chapter includes recommendations from the study and implications and limitations learned during the study.

Discussion

To answer the two research questions, both quantitative and qualitative data were combined using a convergent parallel mixed method design as described in Chapter 3. The data were reviewed along with information discovered in the literature reviews undertaken in conjunction with the research. The following discussion is organized by the two primary research questions associated with the study: (a) Research Question 1: How does the implementation of the use of advanced graphic organizers and the use of a spreadsheet tool to manipulate authentic data impact the quantitative literacy skills of 11th grade honors level history students at SHS? and (b) Research Question 2: What are the 11^{th} grade honors level history students' perceptions about the effectiveness of

incorporating situated data sets into graphic organizers in order to increase their quantitative literacy skills?

Research Question 1: How does the Implementation of the use of Advanced Graphic Organizers and the use of a Spreadsheet Tool to Manipulate Authentic Data Impact the Quantitative Literacy Skills of 11th Grade Honors Level History Students at SHS?

Quantitative literacy (QL) skills are important for the success of today's high school students, but they are often taught distinctly and separately from other courses (Milou, 2020). Because of the limitations of current curriculum standards and the fact that many teachers do not possess the requisite skills to teach QL, often the tools necessary to learn valuable QL skills are not used in conjunction with other non-math subjects, such as social studies (Bennison, 2015; Geiger, Goos and Forgasz, 2015; Steen, 2001). The purpose of this research was to combine QL skills with authentic data from current history topics and have the students practice combining both areas of content knowledge.

Using elements from Mishra and Koehler (2005) Technology Pedagogy and Content Knowledge (TPACK) framework, an intervention was planned that combined the use of a spreadsheet (technology), student use of graphic organizers (pedagogy), and the historical data from the current course curriculum (content) into a series of lessons. Research question one is discussed further in the following five sections: (a) quantitative literacy, (b) spreadsheets, (c) technology platforms, (d) graphic organizers, and (e) use of authentic data.

Quantitative Literacy. As indicated in Chapter 1, the goal of increasing student quantitative literacy skills was the focus of the problem of practice which precipitated this action research and my personal goal for students. Quantitative literacy skills are important for student success in high school, college, and beyond. Studies have shown that adult quantitative literacy skills are inadequate and competency in QL affects long-term financial success (Tout, 2020). and healthcare decisions (Nayak, Hartzler, MacLeod, Izard, Dalkin & Gore, 2015). "Compared with mathematics, which is a discipline to be studied, quantitative literacy is more a habit of mind characterized by a person's motivation to use quantitative information and shaped by his or her beliefs, values, and attitudes related to mathematics" (Wilkins, 2009, p.2). In other words, students need to connect mathematical skills and content from other courses together to enhance and enrich the learning of both while developing their QL prowess (Crowe, 2010; Steen, 2001).

This action research program focused on specific QL skills, primarily the interpretation and application of charts and graphs, to enhance social studies learning. The interpretation of charts and graphs is a small part of the overall scope of QL (Steen, 2001), but it was chosen for the intervention because of problems observed with the concept in previous high school classes I have taught. Although the analysis of the pretest-posttest scores did not conclusively confirm that the intervention significantly increased student knowledge of QL skills in the areas of chart and graph analysis, discussions with the students, both formally and informally, suggested that they did learn important skills. Since the intervention, the class has focused at least one time per week on the use of charts and graphs to enhance a particular point of emphasis in a classroom

lesson, and charts and graphs have been included on all formative and summative assessments.

Analyzing charts and graphs created from pertinent historical data, related to what the students are currently studying is important (Ojose, 2011). The analysis engages both cognitive and affective skills as students examine and discuss the implications of the data. “The cognitive and affective component of numeracy includes the processes that enable an individual to solve problems, and thereby links the context and the content” (Ginsburg, Manly & Schmidt, 2006, p. 20). Not only do the charts and graphs provide a visual component to the data, but they also help build multiple skills. Ginsburg, Manly and Schmidt (2006) state:

> In numeracy, context is the critical factor, so the focus of algebraic content for numeracy are those concepts that will help to build the reasoning, skills, and strategies that enable a student to interpret the mathematical demands of situations of the real world. (p. 15)

Participants in the study acknowledged increases in QL during the focus group and in informal settings. During the focus group, Samantha discussed how learning formulas helped, Jill added that she understood charts much better, and Sissy claimed that the use of the charts and graphs helped her learn the history involved. Even participants, like Sissy, who scored lower on the posttest acknowledged a general sense of improvement in QL knowledge and application.

All 14 participants appeared to have engaged in cognitive learning as demonstrated by their ability to make connections between charts and other forms of data and referred to cognitive skills such as analyzing, estimating, and applying new

knowledge to current and future learning. Students also indicated they had a newfound confidence and were better able to explain the concepts to others and apply the skills to new situations and problems. The student's ability to recognize their own increases in factual, conceptual, and procedural knowledge indicate that learning has occurred during this intervention process (Pickard, 2007).

Spreadsheets. As part of the planned intervention, the use of a spreadsheet was chosen as the primary technology tool for presenting the intervention lessons. Originally, Microsoft (MS) Excel was the spreadsheet of choice, but because the students were primarily going to use their school-issued Chromebooks, Google Sheets was chosen as the instructional technology. The graphic organizers and formulas were adjusted to replicate the processes used by Google Sheets. The creation of charts and graphs is also quite different between MS Excel and Google Sheets and all charts and graphs were created and explained using the Google Sheets methods and terminology.

The use of the spreadsheet was planned to aid in the development of student's QL skills. "First, the notion of teaching with spreadsheets has wide appeal for combining mathematics and context—regardless of whether that means bringing context to math or bringing math to context" (Vacher & Lardner, 2010, p. 1). The use of a spreadsheet is quite common in high school courses, but generally only using rudimentary functions, basic formulas, and limited analysis. In the initial student demographic survey, all 14 (100%) of the students reported using Google Sheets during their high school courses, while only five (36%) claimed to have used MS Excel. Eleven students reported using a spreadsheet in science class, while eight (57%) had used spreadsheets in math and

financial literacy. Only six (43%) of the students reported use of a spreadsheet in social studies, but none could recall the activity.

When asked about their proficiency in using spreadsheets, using a Likert scale ranging from 1 (N*ot Skilled*) to 5 (*Highly Skilled*), the students thought themselves most proficient in making financial decisions using data (*M = 3.80, SD = 1.80*), followed by interpreting charts (*M = 3.47, SD = 0.64*) and creating charts from data (*M = 3.20, SD = 1.08*). According to conversational student feedback, most of them had not created a chart or graph using a spreadsheet for social studies.

The spreadsheet was identified early on as a "mindtool" (Jonassen, 1999) because it forced the user to manipulate, rather than simply enter and edit data. "Mindtools scaffold different forms of reasoning about the content that students are studying. That is, they require students to think about what they know in different, meaningful ways" (Jonassen, 1996, p. 1). The spreadsheet can also be used to forecast, plan, and illustrate data easily, and the user can create new, meaningful data from existing data entries. "Spreadsheets are flexible Mindtools for representing, reflecting on, and calculating quantitative information. Building spreadsheets requires abstract reasoning by the user, they are rule-using tools that require that users become rule-makers. Spreadsheets also support problem-solving activities…"(Jonassen, p. 5). With a spreadsheet, a user can also examine the raw data underlying charts and graphs and verify the validity of the displayed data. "It is of crucial importance to the learning process that students are able to interpret graphs fluently and without error" (Beare, 1994, p. 583).

As described below the use of spreadsheets offers a tremendous opportunity for student learning and engagement with a variety of cognitive learning activities:

> Spreadsheets…have a number of very significant benefits many of which should now be apparent. Firstly, they facilitate a variety of learning styles which can be characterized by the terms: open-ended, problem-oriented, constructivist, investigative, discovery-oriented, active, and student-centered. In addition, they offer the following additional benefits: they are interactive; they give immediate feedback to changing data or formulae; they enable data, formulae, and graphical output to be available on the screen at once; they give students a large measure of control and ownership over their learning; and they can solve complex problems and handle large amounts of data without any need for programming. (Beare, 1993).

While the spreadsheet was used to enter and manipulate data, the primary focus during the intervention was to support the study of charts and graphs. While basic spreadsheet skills were not evaluated during the intervention, the analysis of charts and graphs was a major portion of the lessons. Charts and graphs are a useful way of conveying information about data and relationships because they convey it visually and in a concise and compact form. "It is easy for us to assume therefore that graphs of various types are the easiest and most effective form of communication for students, whether appearing on a computer screen or in textbooks" (Beare, 1994, p. 583).

Students showed some improvement and gains in knowledge with posttest scores exceeding pretest scores. The mean score for the pretest was 62.45 (*SD = 20.14*) and the mean score for the posttest was 68.37 *(SD = 13.09)*. Although the paired sample t-tests did not verify that the intervention had in fact increased in knowledge, t (14) = -1.89, p =

.08, the student feedback in both the focus group interview and exit slip responses told a different story.

Samantha's opening comments in the focus group interview suggested "at first I didn't really understand the information but having tables and picture charts and a bunch of graphs like that helped me understand what was going on and what the data meant." Abigail added "I can now look at different kinds of charts and figure out what they are showing much better", and Tom echoed the sentiment with "I understood I feel like I can understand charts and graphs better now."

Technology Platform. When the intervention began, most of the students were in school, using their Chromebooks, while some were at home, using either the Chromebook or a personal device, including desktop PCs, MacBooks, or other laptops. It became evident early on, that the type of device being used affected the instruction, primarily related to screen size, screen resolution, processing speed, and wi-fi connectivity. The size of the monitors of the Dell-issued Chromebooks was 11.5" which is a small surface, and often the size required the students to enlarge the images presented in class and made working with the graphic organizers more difficult. Although the screen resolution was by default 1366 x 768 pixels per inch, which made the images smaller, which added to the difficulty encountered by at-home participants. More importantly, many of the students found it difficult to join the Google Meet, open the required screens (pages), and edit the graphic organizers quickly or efficiently.

Participants commented that the Chromebooks negatively impacted the amount of work they could do at one because of the slow wi-fi, the ability to move quickly between tasks or screens, and the resolution of the lesson material. After the second intervention

lesson, the school went to all remote learning for two separate two-week periods, which also affected instruction.

In addition to the problems mentioned above, being at home affected student engagement and teacher instruction. Students were unused to the full instructional periods online and the feedback and questions were noticeably diminished while the students were at home. Students tended to ask more questions about data entry than they had before the remote assignment, mostly based on their inability to see a formula, or result, from the instructor's on-screen image. There were more student complaints about not being able to hear than when in the school setting.

Education experts insist that technology is important to the learning process and must be included in routine instruction (Archer et al., 2007); Mishra & Koehler, 2005, 2009). When technology works well, it is indeed a benefit to instruction. To the extent that teachers perceive technology in instruction as directly relevant to their curriculum goals (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012) and favorable to student learning (Hur, Shannon, & Wolf, 2016), they are likely to integrate it (Margolin, Pan & Yang, 2019). Stated more directly:

> It is time to shift our mindsets away from the notion that technology provides a *supplemental* teaching tool and assume, as with other professions, that technology is *essential* to successful performance outcomes (i.e., student learning). To put it simply, effective teaching requires effective technology use (Ertmer & Leftwich, 2010, p. 256).

In social studies particularly, teachers are still slow to adapt new technology (Hammond & Manfra, 2009), and many still use technology to support traditional

teaching methods, rather than reform it (Whitworth, High & Berson, 2003). "Although technology has the potential to revolutionize social studies education, that potential has not yet been realized in most classrooms" (Beck & Eno, 2012, p. 73). In this intervention, the use of technology has been appropriate for student learning, because it has allowed students to make informed decisions and discover new concepts on their own. But the physical challenges created by the specific setting created by the COVID-19 pandemic, caused the technology to inhibit, or at least slowdown, student learning.

Graphic Organizers. The use of graphic organizers is a commonly used pedagogy for instructional delivery. There is more than enough research evidence and practical advice suggesting that these visual representations of content are useful for students in the learning process (Lapp, Wolsey, & Wood, 2014). The graphic organizer allows the student to track the progress of instruction, get a feel for the extent of the lesson and provides scaffolding for learning. Using graphic organizers allows students the ability to see connections between ideas and concepts, thus improving their overall comprehension and ensuring readiness for continued learning (Vaughn & Edmonds, 2006). "Further, a graphic organizer is an effective visual technique that represents a topic, idea, or concept with the help of an image or keyword" (Caldwell, 2020, p 41). Finally, graphic organizers provide learners a method to increase knowledge by building on their current understanding and presenting new information through well-organized, visual models (Ausebel, 1963).

In these lessons, the graphic organizers were based on the contents of each lesson and included both lesson outcomes and structured figures to help students learn how to create and label graphs and charts. The graphic organizers were used as the basis for the

lessons and the lesson plans were written so that all the material on each graphic organizer was covered. Each graphic organizer was prepared in MS PowerPoint, then converted to a Google Slide, using the same fonts, providing some details while requiring students to fill in some parts that were discussed during the lesson. Emily offered "The graphic organizers were helpful to help me understand the information." Tom added, "I think it really helped like seeing pictures and graphs and tables and spreadsheets it helped me understand what was going on better."

Graphic organizers are tools for schema development, memory retention, and scaffolding. The organizers enable schema development by reducing cognitive overload at the beginning of learning by providing learners details about what is important and how it will be learned. Students are aided in memory retention by interacting with the organizer which aids memorization through encoding and rehearsal (Driscoll, 1994). Finally, "Scaffolding is a strategy that teachers use to move learning forward in the zone of proximal development. It is a collaborative process" (Olsson & Edmand-Stalbrant, 2008).

When the students were in school, two graphic organizers were available for each lesson – a paper version and an on-screen version. Tom noted, "I think if we take online out of it, and it was all like paperwork I think that for me personally, it would have been easier to learn the material if it was on paper like the lessons like I know". Samantha added, "I feel like it would help me absorb like the material better if I was writing it on paper". Freestone (2013) noted that students gained higher marks on average when tested on their recall from paper compared to digital sources of information.

The students at home were initially provided only with the onscreen, electronic version. It became evident early on that the on-screen graphic organizers presented a problem for students with smaller screens. Many of the students found it difficult to follow the instruction and fill in the blanks on the graphic organizer based on limitations of the Chromebook technology. When asked to show their completed organizers, some of the students had not made any entries on the organizers, and some had incorrect responses in the student response spaces.

Prior to the third intervention lesson, I printed the remaining four graphic organizers and sent them via regular mail to each student, so they would have the paper version to review and take notes on. Billy responded to this action with “so when that one time that he sent home the graphic organization and that was really helpful”.

Authentic Data. The use of authentic data were important to the development and outcome of the intervention. When planning the intervention, the course weekly schedule was used to make sure that the data used in the intervention lessons did not detract from the content knowledge normally delivered during that lesson or unit. Without the intervention, the students would have received the same instruction, albeit without the same level of emphasis on supporting charts and graphs. The importance of using authentic data is central to constructivism, which emphasizes creating meaning from experience (Bednar, et al., 1991). Ertmer and Newby (1993) insist that “likewise it is essential that content knowledge be embedded in the situation in which it is used” (p. 55-56). When considering data for learning, the choice of meaningful data is important. Abstract concepts usually have a lower degree of perceptibility, which largely accounts for students’ difficulty in learning the concepts (Carey, 2002; Jonassen and Hung, 2008).

In addition, Ojose (2011) adds "Students should be offered real-world situations relevant to them, either real-world situations that help them function as informed and intelligent citizens or real-world situations that are relevant to their areas of interest, either professionally or educationally" (p. 93).

For example, in intervention lesson four we were studying the bimetallism issue in 1896, regarding the gold: silver ratio in the money supply. In previous years, we would simply have discussed the issue, completed simple calculations regarding the ratio of 16:1 [gold: silver], and moved onto the next topic. During this intervention, we: (a) created a chart showing total silver production in the US from 1848-1896, (b) used formulas to calculate tonnage and percentage increases in total silver production, and (c) calculated and compared the ratio of gold: silver at 15:1 and 16:1 to determine the scope of the issue in 1896. After the spreadsheet activities, students were better able to grasp the real issue in the country and why proponents of inflation favored the 15:1 standard over the 16:1 ratio.

The importance of using authentic data is to create a more memorable learning environment for students. When the outcome of the data has personal implications for the students, such as higher test grades, or benefits in real life, learning is strengthened. Not only does the use of authentic data strengthen schema development, but the additional knowledge also makes learning other new items stronger. Thus, using context that emulates real-life problems and settings is fundamental in helping students integrate, analyze, and apply concepts of statistics. "Research has shown that digital technologies most effectively support learning through critical engagement with content, development of cognitive skills and authentic learning tasks relating to students' own experiences"

(Howard, Ma & Yang, 2016). Educational technology can support this approach if used to encourage the construction of knowledge through activities that are socially situated in a meaningful and authentic context (Palincsar & Klenk, 1993; Reid, 1993). When students related the graphs and formulas used to new learning, they also reported an increase in their ability to use the skills in other areas. use the concepts to apply to other areas of learning.

Research Question 2: What are Student's Perceptions about the Effectiveness of Incorporating Situated Data Sets into Graphic Organizers in Order to Increase their Quantitative Literacy Skills?

Student perceptions about what they are learning may be difficult to measure. "Instructors often equate students 'disengagement in class to their disliking the subject; however, issues of engagement may run deeper than this" (Perotta and Bochan, 2013, p. 2). Investigating student perceptions of instructional strategies is a key component of understanding which pedagogies improve engagement. The idea of measuring student perceptions involves understanding the difference between what teachers want from a lesson and what the students want. Perception may be measured through engagement and performance. Teachers may have different expectations for performance which must be clearly presented to, and understood by, the students in order to evaluate perception and engagement. "If differences between teachers and students' expectations of how learning happens and what is being learned are too large, students will be at risk of becoming unengaged and may struggle to develop learning and thinking skills" (Vermunt & Verloop, 1999, p. 277).

Recently student engagement has been described as a strategic process, one which is built around the goal of enhancing all students' abilities to learn how to learn or to become lifelong learners in a knowledge-based society (Parsons & Taylor, 2011). Cognitive engagement is defined by Fredericks, Blumenfeld, and Paris (2004) as a "psychological investment in learning, a desire to go beyond the requirements of school, and a preference for challenge" (p. 7).

Student cognitive learning was measured by their responses to a pretest-posttest assessment and responses to quantitative-based questions in post-lesson exit slips. Informal student feedback was also gathered by asking questions during the lessons and responding to student inquiries during the lesson presentations. Most of the important data collected about student engagement was qualitative in nature, stemming from comments in the exit slips and the focus group interview. The discussion for RQ 2 is divided into three subsections: feedback on the (a) use of technology, (b) use of authentic data, and (c) use of graphic organizers.

Finally, Valentine (2013) stated that "cognitive psychologists studying engagement for many years noted that as students get older and progress through the K-12 learning experience, the pattern of focus during learning time declines" (p. 1). She further added that students are only involved in higher-order, or deeper, thinking for 60-70 minutes per day. Because of the added burden of remote learning, students may have been less involved in higher order thinking as the lessons were conducted. It is too soon to tell about the real effects of the loss or lack of student engagement during the COVID-19 pandemic, but early studies indicate that the learning loss in the switch to fully remote

learning was measurable (Bansak & Starr, 2021; Domina, Renzulli, Murray, Garza, & Perez, 2021).

This limited engagement may be connected to certain times of the day, with less student engagement in the earliest morning classes, and may also be affected by online versus in-person classroom attendance. It was outside the scope of this intervention, largely because it was unexpected, to examine the level of engagement of in-class versus online students, participating in the same learning activity.

Use of Technology. Students reported that they improved in several areas of spreadsheet use, including the use of formulas, creation of charts and graphs and manipulation of raw data. Most students felt confident in their ability to enter and edit data and create and format charts and graphs after the intervention as reported from the initial demographic study and data collected from the Case Study exit slip. When asked after the case study if their spreadsheet skills had improved, students were generally positive about their improvement.

Jonassen (2000) suggested that using spreadsheets is an important activity that enables learners to identify variables and information, to develop formulas, and to use them to perform data analyses to answer their inquiries. Learning about the components of the spreadsheet and how these components help answer the investigation questions provides feedback and encourages the students to reflect on what they are trying to construct. Samantha offered that "in the beginning, I was a little confused on how to read it and how to create spreadsheets but then once I got the handle of it really helped me … get visuals of what was going on". Claudia added, "I learned a lot of new things when we started using the spreadsheets and learning all the shortcuts and using more numbers

in history classes really helps me personally because I consider myself more of a stem student".

Some studies indicate that teachers with a constructivist conception of teaching and learning use technology in the classroom with a student-centered approach (Judson, 2006). There are even studies showing that teachers with more traditional conceptions also tend to use technology with a student-centered approach (Hermans, Tondeur, Van Braak, & Valcke, 2008; Matzen & Edmunds, 2007). This indicates a certain degree of association between classroom use of technology and student-centered practices (Herrera, 2013), which is a significant factor in student engagement.

Research has shown that digital technologies most effectively support learning through critical engagement with content, development of cognitive skills, and authentic learning tasks relating to students' own experiences (Lowther, Inan, Ross, & Strahl, 2012; Ottenbreit-Leftwich et al., 2010; Wang, Hsu, Campbell, Coster & Longhurst., 2014). Students have stated that visual reinforcement and representation using technology was the best way to strengthen learning (Wynn, 2013). Because student engagement can be understood as the cognitive process, active participation, and emotional involvement in a learning procedure (Pellas, 2014), student engagement can be increased through the considered use and presentation of technology, pedagogy, and content knowledge. Student engagement seems to rise when learning is beneficial to them, as Catherine acknowledged the use of authentic data and charts strengthened the retention of the learning and increased interest.

Use of Authentic Data. The students understood the value of the use of situated data in learning the skills presented during the interventions. Billy postulated that the use

of timely historical data in the lesson increased his understanding of the topic and Claudia confirmed the thought. The use of charts, graphs, and spreadsheets to increase the retention and learning in history classes has been studied sparingly. According to van Drie and van Boxtel (2008), in order for history students to become adept at higher-order thinking skills, they must be able to interpret and situate information within its historical context.

The use of authentic assessments is important in social studies, also, because it gives the students the opportunity to study the learning in a realistic scenario (Brown, Collins & Duguid, 1989), in which all learning elements lead towards a coherent conclusion. "Authentic problem-solving opportunities abound with the use of historical and current data" (Coleman and McMurtrie, 2017, p. 6). This sort of inclusion of authentic data requires knowledge from both math and social studies content. The relevancy of a math lesson is enhanced by integrating thought-provoking social studies data.

Use of Graphic Organizers. The use of graphic organizers was chosen for this study because the organizers themselves play a variety of roles in learning. Perotta and Bohan (2013) in their study of graphic organizers hypothesize that:

> Research shows that instructors who provide college students with opportunities to interact with peers and multiple texts make history content relevant to their life experiences and prior knowledge, thus improving engagement. Active-learning strategies also aid in honing skills that are necessary for students to improve engagement and comprehension of historical information. These skills include, but are not

> limited to, analyzing primary sources, reading, and writing comprehension, conducting research, and critical thinking (p. 2).

Graphic organizers in their basic form help students by organizing and structuring notes and thoughts and may act as a concept map for the topic under consideration, or help activate prior knowledge (Hawk, 1986). Graphic organizers may also facilitate learning and recollection of new material to support meaningful learning by transferring abstract concepts to concrete concepts and connecting new information with old existing information (Ausubel, 1968; Mayer, 1979). During this presentation, the use of the organizers was more along the lines of presenting and clarifying relationships between content (charts and graphs) and sub-content (underlying spreadsheet data) and the relationship to other content areas (authentic data tied to the current class lesson progression.

When asked about the use of the graphic organizers in the intervention, students were generally positive. Billy remarked, “I feel like I definitely learned a lot through these graphic organizers and these charts and everything and it's definitely going to help me throughout life no matter what I do”. Students’ enthusiasm for technology, including electronic devices and computerized gadgets, has resulted in educators creating more modern digital versions of traditional evidence-based strategies such as graphic organizers and other direct instruction techniques, but there is limited evidence to measure their effectiveness (Kennedy et al., 2014).

Implications

Action research is practical, personal, and limited and as such can be used in limited settings. The research, however, can be used to engage in further study that could uncover larger ideas and practices. One of the primary purposes of action research is to inform practice (Tripp, 2005) that examines beliefs (Manfra, 2019). Action research is a process in which a specific problem is identified, and an experimental intervention designed and tested with a view to gaining insight into the problem and ultimately solving it (Elliott, 2001; Kember, 2000). According to Manfra and Bullock (2014), action research "can provide a powerful means for bridging the divide between theory and practice and encouraging practitioners to engage in innovative practices (p. 161).

The discussion of the implications learned from the action research are separated into three subsections: (a) personal implications, (b) implications for school, and (c) implications for future research.

Personal Implications

The initial concept behind this action research was to examine ways of increasing QL in high school students. While QL skills involve some basic math skills, they apply the skills to practical applications, and ultimately may be applied to reasoning in larger areas, such as social justice. Crowe (2010) writes that:

> Numeracy is as essential to becoming an active and thoughtful citizen as literacy. Although the concept of numeracy is complex and robust, there are four areas in which teachers can fairly easily begin to incorporate it into social studies curriculum and instruction. The areas include the students' ability to understand raw numeric data in context, to understand

percentages in context, to understand the meaning of average, and to interpret and question graphs and charts. The author shares ways to cultivate numeracy in the social studies education classroom related to each of these four basic aspects of numeracy (p. 105).

It is imperative then that social studies teachers understand the role of QL as it applies to critical thinking in US History and economics and make plans to include it in our content lessons and develop both pedagogical and technological platforms to deliver meaningful lessons to our students.

The intervention created for this action research was based on the literature about the teaching of QL. "The most common activity in a social studies classroom should be the analysis of primary sources. Students are intrigued and engaged by edited and unedited documents, written statements, transcribed speeches, photographs, pictures, charts, graphs, cartoons, and even material objects" (Singer, 2012, p. 1). The lessons in this study involved primarily the analysis of charts and graphs but added choropleths (maps as data instruments) and population pyramids, both of which extended the ideas of using QL to other areas in the study.

The literature also proposed the idea that "Standardized educational assessments are measurement instruments designed to quantify test-takers' abilities in areas such as literacy and numeracy" (Howard, Ma & Yang, 2017, p. 2). This thinking extends the importance of learning QL skills beyond the mere acquisition of knowledge about social studies topics but also increases the likelihood that students will do better on mandatory state tests, such as the PARCC in NJ, and the national assessments including the SAT and ACT (Peters et al, 2006).

During the course of this action research, I have taken copious notes on how to improve the application of the intervention to future classes. These field notes, or observational data, have been incorporated into my revised lesson plans for next year's intervention. My field notes have generally complemented my inquiry data, interviews, and exit slips, which was collected specifically to address the overarching research questions. Some of this data overlapped and provided a "framework for delineating the various forms of data in the action research process" (Manfra & Bullock, 2014, p. 165).

My personal notes have been invaluable for restructuring the next round of this research. The most important change I will make is to extend the intervention to a full-year activity, including more topics, strengthening the ones that were included in this round, and discussing the findings with the students in more detail.

I also realized many of my own pedagogical and technological shortcomings as a teacher in the project and will make amends to correct those deficiencies. I had very high expectations for my students, as I do for all of my upper-level classes, and expected too much from them, especially during the periods of remote learning.

For instance, I added too much detail to the organizers and did not allow for the additional time required by the hybrid classes to completely cover the material. I tended to overestimate the amount of new knowledge students can absorb and comprehend at one sitting, especially during the remote instructional periods, and underestimated the impact of distractions or extended discussions on lesson effectiveness.

Implications for School

My goal would be to share the knowledge with other teaches in the department and ultimately across the various departments to encourage cross-curricular instructional

activities. With my own department, I would like to share the goal of increasing QL in students and the reasons behind doing so. Finally, I would like to share the actual intervention tools and encourage my fellow social studies teachers to implement at least one of the lessons to introduce students to the idea of mixing data analysis with social studies. “Proponents of practical action research argue that through reflection on practice, teachers can generate knowledge about teaching and learning. Implicit is the emphasis on the practicality of action research for teachers and schools (Manfra & Bullock, 2014, p. 164).

I hope to avoid the following scenario among my fellow social studies teachers and among social studies classrooms in general.

> Students arrive in their next class, American History, where they become engaged (or not) in a lesson about World War I that is devoid of reference to matters of quantity. Basic mathematics could be used to investigate the size or duration or probability of many wartime phenomena, which would deepen students’ understanding of their impact. But the teacher passes on these opportunities, as is no surprise to the students, who have heard this teacher declare himself “not a math person.” (Creating and Sustaining a Culture of Numeracy, n.d., p. 8).

The idea is followed up later in the same article, by stating that “it is understood that numeracy is everybody’s business” and “All school personnel use mathematical language, speaking about number sense, percentages, ratios, proportions, and data analysis, which promote student fluency and familiarity with such terms” (Creating and Sustaining a Culture of Numeracy, p. 9).

According to Cochran-Smith and Lytle (1999), "practical inquiry is more likely to respond to the immediacy of the knowledge needs teachers confront in everyday practice and to be foundational for formal research by providing new questions and concerns" (p. 19). Hendricks (2009) stated, "the methods of data collection in action research fall into three overarching categories: "artifacts, observational data, and inquiry data" (p. 81) and "Artifacts are items created by participants and usually fall within one of three subcategories: "student-generated," "teacher-generated," and "archived" (p. 82).

Implications for Future Research

After reviewing chapter two and searching for new research articles, there are still very few studies focusing on social studies teachers and fewer about social studies and the introduction of QL practices and goals in particular. As a result, we know comparatively little about those who are responsible for teaching civics to the next generation of young citizens and how they may differ from other educators (Brookings, 2018).

Social studies teachers should provide students opportunities for in-depth investigation of concepts that challenge and engage them. Challenging social studies instruction includes research, debates, discussions, projects of all varieties including the arts, and simulations that require the application of critical thinking skills. Instead of simply reading and answering questions from textbooks, elementary students should be taught to inquire, question, evaluate, and challenge informational sources (NCSS, 2017). Askew (2015) states that a common factor across mathematical literacy, quantitative literacy, quantitative reasoning, and numeracy is the application of mathematics to a

problem in a social context, and so not simply asking whether or not a mathematical model is fit for purpose, but what defines that purpose in the first place? (p. 709).

Much has been said about the competency and comfort level of non-math teachers attempting to teach QL to their students. The teacher's own understanding of how math is applied in out-of-school contexts may make it difficult for them to provide students with the learning experiences necessary for them to adapt the knowledge they learn in school to the outside world. Steen (2001) argues that for students to become numerate, they must engage with tasks that demand the use of mathematics in multiple contexts, and effective numeracy instruction must take place in all school subjects, not just mathematics. This means that a teacher must have the capacity to recognize when a numeracy [QL] opportunity arises and the skill and disposition to take advantage of such opportunities.

A good deal remains to be explored about what exactly the nature of the graphic organizers should contain in applying this type of intervention and what type of data, charts and graphs engage students more than others. While graphic organizers tend to be grouped into specific types, such as KWL, concept maps, or fishbones, there are no universally acceptable graphic organizers. Each teacher creates organizers suitable for the task(s) at hand, which makes the comparison of the organizers difficult. In addition, graphic organizers engage different levels of cognitive and affective learning, which makes both creation and analysis of the organizers difficult to compare.

Finally, Cherner and Smith (2015) asked questions about the use of technology in general, which applies to graphic organizers. "Are students replicating a paper-and-pencil task using technology?" and "Is technology being used to provide an eLearning

experience that can only exist in the digital realm?" These relate to similar questions posed in the Substitution, Augmentation, Modification, and Redefinition (SAMR) model by Puentedura (2012). In the first case, the act of filling in the graphic organizer, even if it is online, is at the lowest level of technology use, simply substituting a computer for the pen/paper alternative. Using the technology to explore the concepts contained in the graphic organizers and filling them in approaches the Modification level.

Limitations

Methodological Limitations

The results from the pretest-posttest were unexpected and difficult to explain. Although the same students took the same pretest-posttest assessment, the posttest scores varied unexpectedly. There has been criticism of the entire pretest-posttest evaluation, based on several factors. One useful way of representing student test-taking behavior has been defined by expectancy-value models of achievement motivation. Expectancy is the student's belief that he or she can successfully complete the assessment, and value embodies the beliefs a student holds as to exactly why he or she should try to complete the task successfully (Wise & DeMars 2005). When the outcome of the test has great value to the student, and the assessment tool is well-designed, demonstrated levels of proficiency are a good proxy for actual levels of proficiency (Wise & DeMars 2005). However, some research has shown that students do not perform to their actual levels of proficiency on low-stakes tests (Wise & DeMars 2005; Cole, Bergin, & Whittaker 2008).

A criticism of the use of the pretest-posttest approach to measure student learning is that students will necessarily perform poorly on the pretest since they know nothing about the material at the beginning of the course; the lower the pretest score the higher

the potential learning gains (Pascarella and Wolniak 2004; Warren 1984). Posttests under such conditions will always show improvement over the pretest (Boyas et al., 2012). Additionally, statistical analysis of pretest-posttest results presumes that the frame of reference of the student has not been altered by the course content, hardly a realistic assumption (Mann, 1997).

Move to Remote/Hybrid Classrooms. The intervention was planned assuming that all students would be present in class during the entire presentation, using paper handout versions of the graphic organizers and following spreadsheet data entry and graph creation on a large Smartboard at the front of the classroom. The classroom environment is conducive to teacher-student interaction and students will ask for help to avoid getting behind in the lessons. It is also easier to see when students are struggling in the classroom by observing their behavior and mannerisms. When confronted, in the classroom, students will usually ask questions and seek clarification from me or one of the other students in the room. In the classroom, I can also walk around and observe student activity and field questions privately if a student needs discretion.

The sudden switch to the completely remote environment based on COVID-19 levels in October changed the physical, mental, and interactive environment. I could sense instantly that the student engagement had declined and although the awareness is anecdotal, the results were palpable. Students were more likely to join a Google Meet late, even when they would not exhibit the same behavior in person, which further reduced the amount of instructional time. Already there have been studies investigating the lack of student engagement during the recent pandemic, and some have already shown the changes in student engagement.

Another implication of the switch to a hybrid schedule was the loss of instructional and recovery time. Before March 2020, our high school had followed a fairly well-defined pattern of instruction. The schedule revolved around six blocks of instruction each day, with three 55-minute classes in the morning and a second set of three 55-minute classes in the afternoon. Each day two of each student's eight courses were omitted from the schedule. On A days for example, periods 1, 2, and 3 were conducted and in the afternoon periods 6, 7, and 8 were conducted. On B days, however, the morning schedule included periods 2, 3, and 4, while the afternoon covered periods 7, 8, and 9. Over each four-week period the class met 15 times, for approximately 13 hours and 45 minutes.

In the hybrid schedule, every class meets less often. For two weeks of every four-week rotation, each class meets in the morning for three 55-minute classes, and one 35-minute class in the afternoon. In the second week, the classes meet for two 55-minute morning classes and one 35-minute class in the afternoon. Therefore, over four weeks, each class meets for a total of 14 times (4 of the meetings are ½ hour), for 12 hours of instruction. Over a period of 40 weeks, the entire school year), the hybrid schedule has 70 less hours of instruction than the normal schedule. This matters because there is significantly less time to reinforce the lessons learned during the intervention and to get obligatory requirements completed as well, which include 10-17 graded assessments each marking period (10 weeks).

Limitations of Chromebooks. As mentioned earlier, the intervention was planned for presentations to students in class, where charts, graphs, formulas, graphic organizers, and other materials would be presented on a large Smartboard, where students

could follow the instruction on the Smartboard and then perform the actions on their Chromebooks. In each classroom is a dedicated wi-fi server that enabled students to work effectively on their Chromebook while in class. Outside of the classroom, where students are depending on a variety of wi-fi and internet connections, the Chromebooks were tasked to provide a connection to the class meeting, download, and display course material, zoom into and out of small graphic organizers and to allow students to hear the class conversation clearly. Students were expected to deal with these limitations while listening to instruction, entering, and editing data, and completing graphic organizers. Billy offered the following assessment of the difficulties with the Chromebook – "when I was doing the online graphic organizer, I would always have to zoom into the slide so that I can input the answers but that would always cause problems because then my computer would act weird."

Viewing a single activity on an 11" screen can be a daunting enough task for the best-visioned students but having multiple tabs to view on a small screen is much more difficult. Even if the student is highly proficient with the device, the screen size still requires the students to locate a specific tab, open it, make appropriate adjustments, and match the instruction to the place on the screen, which reduces the ability to learn.

One of the limitations of working with Google Sheets is that the entry bar for entering formulas always displays the formulas and other entries in a small font, which is hard to see when using the program, but exacerbated when viewing it on a Smartboard or small Chromebook screen. To correct that, I always wrote the formula without the leading "=" in large text so the students could see them, but then had to take the time to edit the entries so the formulas could work properly.

Student Engagement. Although the evidence is largely anecdotal, the lack of student engagement while students were online was very noticeable. While in class, during the first two lessons, students were engaged and asked questions about the processes they were learning and specific questions about data entry and topics were discussing. However, once we went to the fully remote schedule, student participation dwindled considerably. During the full remote cycle, it was hard to gauge whether students were working on the graphic organizers and other classwork that was assigned. Like many other teachers across the country noted, the students would not fully appear on camera and asked very few questions. They did, however, produce their assignments, including the follow-up exit slips after each intervention lesson.

I selected the US II Honors class for the study because there were 20 students in the class, and I felt they would be excited to work with the study as an alternative to their other course classes. I deliberately did not choose to work with my AP history classes because I knew the AP exam would be affected by the pandemic and did not want to jeopardize their success on the exam. The lack of engagement, however, was echoed across the school district, area, region, state, and by teachers nationwide.

Limitation of Findings

As widely known, the findings of action research are not normally generalizable. The limited number of participants, the uniqueness of the intervention, the use of researcher-developed surveys and other data instruments and the unexpected shift across several learning environments over the course of the intervention diminished the ability to replicate the study.

Technology choices. The technology platform chosen for this action research was the Dell Chromebook, issued by the high school to each student. While the students were in school, they used the Chromebooks in class, while at home they used a variety of personal computing devices, including MacBooks, desktop PCS, tablets, and even smartphones. Based on the screen size and resolution alone, students were accessing and processing the learning materials quite differently. Although the intervention used technology for all three of its intended purpose, not all students were able to access, view or process the instructional materials in the same way.

While each student was able to participate in each of the three main technology typologies, the Chromebook users may have been at a disadvantage. Tondeur et al., (2008) identified a typology of actual uses of computers in primary education based on three factors: basic computers skills (to develop students' knowledge of information technology), computers as information tools (for research and data gathering), and computers as a learning tool (to put knowledge and skills into practice). Although the intervention focused on the third concept, all three skills were used. The differences in platform capability, however, play a role in the ability to learn, which should be the subject for future research.

Evaluating positionality and reflexivity. In qualitative research it is assumed that the researchers make a difference in the findings of their studies; objectivity is not present. In fact, it is often said that the researcher is the research instrument (Peshkin, 1988; Slotnick & Janesick, 2011) and the relationship of the researcher to the material being studied should be considered (Creswell & Creswell, 2017; Mertler, 2014). As the researcher, I chose or created all of the instruments used in the intervention and had

expectations about the outcomes. I was intentional, particularly during the qualitative analysis, to not steer the coding and categorization process based on my expectations, but to allow the coding process to reveal the themes.

I was somewhat disappointed in the move to full remote learning so soon in the intervention cycle, and had some difficulty determining exactly what the impact of the online learning would be, since I had not rehearsed or considered the possibility of going to a completely online status. I was somewhat frustrated with the limitations of the online setting and tried to not let that cloud my interpretation of the student feedback or lead the students to address the issues during the focus group interview.

Lack of studies in the field. Two years after literature review, there are few additional studies in the area of the combined use of technology, spreadsheets, graphic organizers, and numeracy. I could find no additional studies using the specific combination of activities, concepts, and outcomes that were used in this study. QL, or numeracy, is still not widely regarded as a “core subject” and many teachers, outside of math classrooms, undertake the teaching of QL (Crowe, 2010).

Choices for numeracy topics. The topics were chosen by me and may not be representative of those taught by all teachers, specifically by social studies teachers. I limited the intervention primarily to basic spreadsheet introduction followed by interpretation of charts and graphs. This aligns with the general definitions of QL, which break the subject into four main components: developing confidence and competence with numbers and measures, understanding the number system and operations, solving quantitative or spatial problems in a range of contexts, and evaluating data in graphs, diagrams, charts, and tables

I also tended to focus on the negative aspects of QL, specifically with regard to the possibility of intentional or unintentional misinformation which is preset in many charts and graphs. Parts of three intervention lessons focused on how to detect misinformation in a chart or graph, and how to determine its veracity. "One way is to embed questions about the ways in which percentages and raw numbers can be deceiving into everyday classroom conversations (Crowe, 2010, p. 107).

Participant choice. The participants were selected from a single class and were limited by enrollment and willingness to participate, which 6/20 (30%) chose not to do, although they participated in every phase of the study, except the focus group interview. These students were in a mid-level course, between the higher-level Advanced Placement (AP) students and the lower-level College Prep (CP) students, which suggests that the findings may be different if the interventions were administered to the other classes. All of the students are digital natives, as ordinally posed by Prensky (2000), having been born into a world fully immersed in personal technology. Digital natives are active experiential learners who like receiving information quickly, are multi-taskers and parallel processers, and prefer graphics first over texts (Ng, 2012).

This particular class indicated that they were in a high enough level math class to at least be able to understand the mathematical considerations used in QL. Three (22%) of the students were in Algebra II, four enrolled in Algebra II with Trigonometry, and seven (50%) taking Precalculus. All of these courses provided enough fundamental instruction in basic formulas, numeric precision and ensured that participants could understand the basic concepts of graphs and charts.

Brevity. The time allotted for the study did not allow for instruction in many QL areas. Little time was available to reinforce or revisit concepts based on time constraints. Generally, one class day per week during the research period was allocated to the intervention lesson, while the other full-day and half-day were focused on other required learning and routine assessments. It was vital to keep on a schedule for each intervention lesson, which did not allow for significant scaffolding activities, discussion, or feedback.

The final intervention lesson was a case study for which the class worked together in five teams of four students each. The case study was all about the COVID-19 crisis in New Jersey and used questions about the impact of the virus in NJ. The questions included graphical analysis, data manipulation and asked the teams to form opinions based on their interpretations. We had one day to allocate to the case study because of the impending Thanksgiving break, and although the teams completed the assignment, it is unclear if they did their best work.

The brevity of the case study collaboration was also detrimental to other areas of learning. According to Nussbaum, Alvarez, McFarland, Gomez, Claro, and Radovic (2009) students who participated in group discussions in the classroom and used technology to write reports performed better in terms of learning achievement than students who did not use technology. During constructivist learning processes, teachers act as facilitators rather than transmitters. Indeed, when students work in small groups, they can contribute to a common understanding and develop verbal and social skills. The case study was an excellent opportunity for students to collaborate in their thinking about the intervention lesson concepts, but the nature of the hybrid schedule and short amount of time dedicated to the study hampered their ability to learn.

More authentic pretest-posttest. The pretest-posttest, while including some authentic data elements, asked many general questions which may have lowered the appreciation of the task for the participants and hence their scores. For instance, the 1st question was about calculating the percentage of miles laid by the Transcontinental Railroad, a topic which had been previously covered in class. Other questions, however, were about purchasing lottery tickets and exercise milestones, which could have purposefully rewritten to describe an historical event or topic covered in class. Even though the pretest-posttest was about general concepts, and the ability to apply concepts in general settings, the focus of the intervention was on the use of authentic data.

The purpose of the overall pretest-posttest was explained but would have been more convincing with inclusion with questions more closely aligned to the topics. The pretest was given before the first fully remote session, but some students took the assessment at home and some at school. Classroom assessments are typically assigned, presented, or administered to classes or groups of students. However, individual differences among students operate as each student perceives and responds to the assignment (Brookhart, p. 28). In this case, it was uncertain if students at home heard and reacted to the same instructions, based on the factors previously discussed in this chapter.

The posttest was administered in two groups – those who were not in the focus group and the eight who were. All of the students not in the focus group took the posttest on Wednesday, December 09, 2020, during our regularly scheduled class time for that week. The focus group participants took the posttest later in the day, on their own time. Both groups met for class for the second regular length class the following day and all

discussed the class topic, Theodore Roosevelt, preassigned before the intervention began. At least one of the non-participating students, apparently clicked through the answers and completed the posttest in four minutes.

There are a number of factors which help determine it a pretest-posttest assessment is beneficial in determining learning outcomes. These factors include: if the course is a required course in the student's area of interest, use of higher or lower-order thinking questions, whether student learned the required material during the intervention or course, and the changes in response-shift bias during the testing (Boyas, Bryan & Lee, 2012; Drennan & Hyde, 2008). For this assessment, student's math level and previous experiences with spreadsheets may have also played a role in their individual responses. Response shift bias is a self-measure of skills assessment, in which students overestimate their skills during the pretest and limit their assessment during the posttest, which may lower the value of the course or intervention (Drennan & Hyde, 2008). One of the drawbacks of statistical analysis of pretest-posttest scores is that the inference is that the student's frame of reference has not been altered by the instruction between tests (Mann, 1997).

Pretest-posttest assessments "involve the administration of tests which are of importance to the institution but of limited personal importance to the individual student" (Boyas, Bryan & Lee, 2012, p. 429). However, research exists addressing the question of whether students are equally motivated to succeed on low-stakes testing and high-stakes testing (Harlen & Crick, 2003). As mentioned earlier, some research has shown that students do not perform to their actual levels of proficiency on low-stakes tests (Wise &

DeMars, 2005), which includes these assessments which did not affect the student's grades or standing in the class.

Student engagement vs. participation. Discussion during the 2020-21 pandemic altered school year has focused on several issues, including the debate between online participation and engagement. Simply logging onto the classroom Zoom or Google Meet counts as participation and class attendance but does necessarily indicate engagement. However, if the student is missing from the screen, or viewed from the forehead up, a teacher cannot tell if they are engaged, participating, paying attention, or concentrating on some other activity. Students have found a way to get around programs like Go Guardian or Hapara. One of the ways to increase engagement is through the effective use of technology, which does not include using the technology simply as a communication tool. Using technology to place more responsibility on students for their own learning experiences results in a classroom where students are more engaged with the material (Warren, 2016). Having students complete exit slips, surveys and graphic organizers does place additional responsivity on students and should increase engagement.

Furthermore, it can be argued that true student engagement means more than students doing what is required to pass an exam or complete a particular assignment. Instead, real engagement is achieved when students become fully invested, have a desire to learn, display a willingness to do the work, and want to gain a rounded understanding of the topic. (Ashwin & McVitty, 2020).

Active learning was the goal of the intervention lessons and the goal was accomplished. In many classrooms, pedagogy supporting active learning is organized

around the completion of a project or problem or set of tasks (Maloy & LaRoche, 2010; Patterson, Lucas, & Kithinji, 2012; Rudnitsky, 2013). The completion of the graphic organizers and exit slips and participation in the case study at the end provided multiple opportunities for active learning. Active learning was diminished by a lack of student discussion, particularly when the classes were in the full remote mode, but overall, the students were engaged in active learning during the intervention.

Closing Thoughts

At the end of the day, and the research, the real story is that the people involved, or not involved, in the story matter. No amount of planning or lesson design will reach every student the same, and although we depend on quantitative data to identify trends, describe responses, and infer connections, the important data lies in the stories that people tell. I had not met any of the participants involved in this action research before the start of class last fall, and my relationship with all of them was colored by the attention on the research project. I cannot make connections and inferences about them before and after the intervention because I did not know them before.

In the same manner, I cannot assume that another class would have produced the same effort, learning, and feedback that this group of participants did. The pandemic forced us into a relatively unknown dynamic and gave us little time to reflect on the previous remote instruction issues we had at the end of AY 2019-20.

For the next cycle of this action research, I will create better Likert Scale questions to better explain students' thoughts after the classes. I will create different focus group questions and better demographic questions to gain more insightful data from the students. I will reduce the amount of data on a given graphic organizer to aid in

reducing cognitive overload and to compensate for weaknesses in the Chromebook technology. I will spread the lessons over an extended period, provide better feedback and create alternate assessments to further strengthen learning. Before the intervention, I will assess spreadsheet knowledge, including the entering and editing of data, and ensure that students can create and edit basic charts. I will supplement the authentic historical data with additional historic analysis to ensure that students are continuing to learn history and QL skills simultaneously and most effectively.

Conducting the research convinced me of my original problem in practice, former students admitted limitations in their QL skills which hurt them along their education, careers, and life. In an economic course I took over 30 years ago, my instructor said that over 97% of the American people are financially unprepared for retirement, and over the years the sentiment has been confirmed repeatedly. Bernheim (1996) states that "the existing literature demonstrates that the typical American knows little about their personal finances and their choices reflect their ignorance (p. 43). While part of the problem is spending and saving habits, a lot of the issue is the inability to use QL to interpret instructions, facts, advertisements, and warnings associated with retirement preparation. The problem with retirement, and with health related QL is that the lower the socioeconomic status, the more difficult it becomes to decipher the numbers around us. If honors-level students struggled with the concepts, lower-level classes might struggle even more.

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APPENDIX A

MINDTOOL MATRIX FOR SPREADSHEETS

Table A.1 *Spreadsheet Mindtool Functions, Jonassen (1996)*

Critical Thinking Skills	Filling in a Spreadsheet	Designing/Building a Spreadsheet	Speculating with Spreadsheets
Evaluating			
Assessing Information		X	
Determining Criteria		X	
Prioritizing			
Recognizing Fallacies		X	X
Verifying			
Analyzing			
Recognizing Patterns		X	X
Classifying	X	X	
Identifying Assumptions			X
Identifying Main Ideas		X	
Finding Sequences			X
Connecting			
Comparing/Contrasting			X
Logical Thinking		X	X
Inferring Deductively		X	X
Inferring Inductively			
Identifying Causal Relationships		X	X
Creative Thinking Skills			
Elaborating			
Expanding		X	
Modifying	X	X	
Extending			X
Shifting Categories	X	X	
Concretizing	X		

Critical Thinking Skills	Filling in a Spreadsheet	Designing/Building a Spreadsheet	Speculating with Spreadsheets
Synthesizing			
Analogical Thinking			X
Summarizing	X	X	
Hypothesizing			X
Planning		X	
Imagining			
Fluency			
Predicting		X	X
Speculating			X
Visualizing		X	
Intuition			X
Complex Thinking Skills			
Designing			
Imagining a Goal		X	X
Formulating a Goal		X	X
Inventing a Product		X	
Assessing a Product		X	X
Revising the Product	X		
Problem Solving			
Sensing the Problem			X
Researching the Problem		X	X
Formulating the Problem		X	X
Finding Alternatives		X	X
Choosing the Solution		X	
Building Acceptance		X	
Decision Making			
Identifying an Issue			X
Generating alternatives			X
Assessing the consequences			X
Making a choice		X	
Evaluating the choices		X	

APPENDIX B

STUDENT DEMOGRAPHIC SURVEY

1. Gender : Male / Female

2. Age:

3. Primary Choice After High School:
   Work
   Work, then College
   Community College, then College
   College (4 Year)
   Technical Degree
   Advanced Degree

4. Highest Level of High School Math:
   Algebra II
   Algebra II/Trigonometry
   Business Math
   Precalculus
   Calculus
   AP Calculus AB
   AP Calculus BC

5. Highest Level of High School Science:
   Biology
   Chemistry
   Physics
   AP Biology
   AP Chemistry
   AP Physics
   AP Environmental Science

6. Other Business Courses in High School:
   Financial Literacy
   Accounting

7. Have you ever used a spreadsheet in any other class in High School?
   If so, which area of study:
   Mathematics
   Business
   Social Studies
   English/Language Arts
   Science

8. What tool do you primarily use for routine calculations?
   Handheld Calculator (TI-84 or equivalent)
   Cell Phone
   Mental Estimation
   Spreadsheet
   Online Calculator or Convertor

   Questions 9-15 are Likert Type Questions with scale 0=None to 5= Very.

9. Quantitative literacy is the ability to apply mathematical concepts to everyday problems. How likely are you to seek a career that is based on mathematic/quantitative literacy?

10. At this moment, would you feel comfortable in a job that relied heavily on math calculations, interpretations, and projections?

11. How equipped are you currently to make good financial decisions for your future?

12. How would you describe your proficiency in creating numeric charts from data?

13. How would you describe your proficiency in interpreting other people's graphs and charts?

14. Do you feel that mathematical skills apply to every job and career you might choose?

15. Do increased technology skills make you better able to resolve numeracy issues (problems that involve calculating a present or future outcome)?

APPENDIX C

STUDENT PRETEST- POSTTEST ASSESSMENT

The pretest-posttest assessment for this information was given to students in the form of a Google Form during two normal class periods for US History II Honors, one for the pretest and another for the posttest. The assessment was not intended to last an entire class period. Students did not have access to the pretest after it was completed. During the pretest-posttest restrictions were placed on the assessment by using Hapara's features of test lockdown and copy prevention. Students were not allowed to have any other electronic or recording devices present to copy the test, so it was preserved for the posttest. The test has 35 questions from various areas of quantitative literacy were covered during the intervention lessons.

Questions:

1. Which of the following numbers represent the biggest risk of getting a disease?
   1 in 10, 1 in a hundred or 10 in a thousand

2. Which of the following is the correct way to write five percent?
   5%, 0.5%, 50%

3. If the chance of being selected in the NBA draft is 0.03 percent, how many college players out of 45,000 might be drafted?

4. If the school parking lottery give 70% of the students in the school a parking spot, how many students out of 350 students will not get a parking spot?

5. If person A's risk of getting a disease is 1% in ten years, and Person B's risk is twice that of Person A, what is B's risk?

6. If you invest $1,000 for five years at five percent semiannually, how much will you have in five years

7. If Ford (Ticker Symbol: F) pays a quarterly dividend of $0.60 on every share, currently valued at $6.70, what percentage of each share is the dividend?

8. If the dividend percentage remains the same, and the stock price increases to $8.15, what is the new dividend payout?

9. If the dividend amount stays the same (0.60) what will be the dividend percentage per share if the share price rises to $8.15?

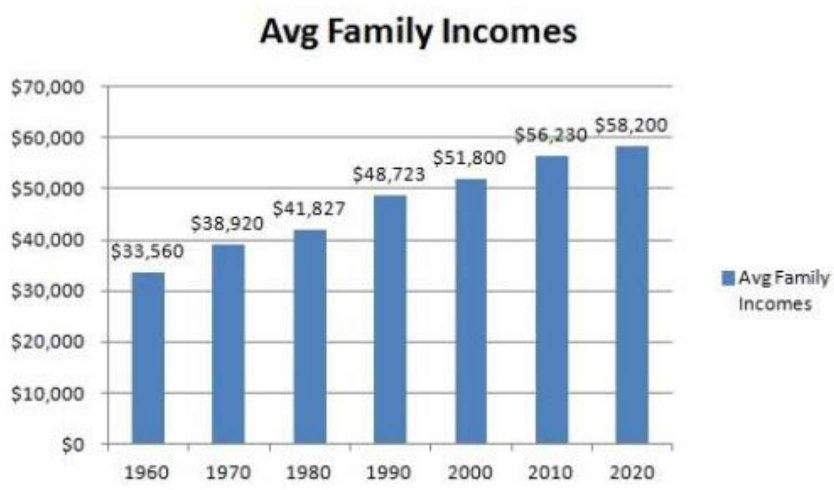
10. Imagine the lottery was based on picking in the correct order, the numbers 1-6. How many tickets would you have to but to ensure you get the winning ticket?

11. The only prize in a lottery is $1,000 and the lottery guarantees that 1 in every thousand players will win a prize. The tickets cost $5.00 each. If 6,284,999 people buy tickets, how many guaranteed winners will there be?

12. Using the information in Question 11, how much revenue will the lottery creator make?

13. Using the information in Question 11 above, how much will the lottery payout?

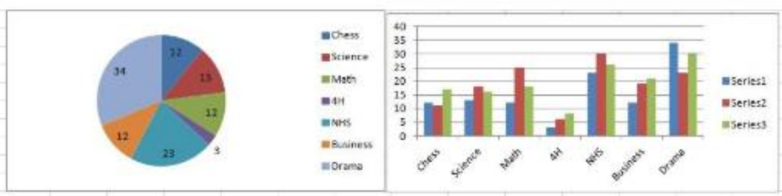
14. The best type of spreadsheet chart for comparing a single genre of CD sales from 2014-2018 is a pie chart. (True/False)



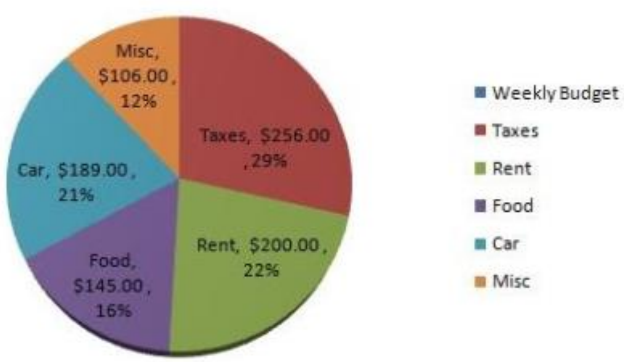
15. From the chart above, you can calculate the actual and percentage increase in average family income for any decade between 1960 and 2020?
True/False

16. The two pie charts shown above represent the prices for daily ski rentals in My Town, USA for June and July,2017. Based on the charts, what fact can be accurately determined?
A) Revenue for the two charts is the same
B) Shop C rented the most skis in July
C) In both months, Shop C had the highest rental rate.
D) June rental prices are lower than July rental prices

Students	2015	2016	2017
Chess	12	11	17
Science	13	18	16
Math	12	25	18
4H	3	6	8
NHS	23	30	26
Business	12	19	21
Drama	34	23	30



17. Based on the raw data, pie and bar chart shown above which of the following can NOT be determined?
A) The bar chart shows data from 2015-2017
B) The bar chart shows the relative popularity of the clubs.
C) The pie chart shows data from 2015 only.
D) The pie chart clearly shows the trends in club membership.



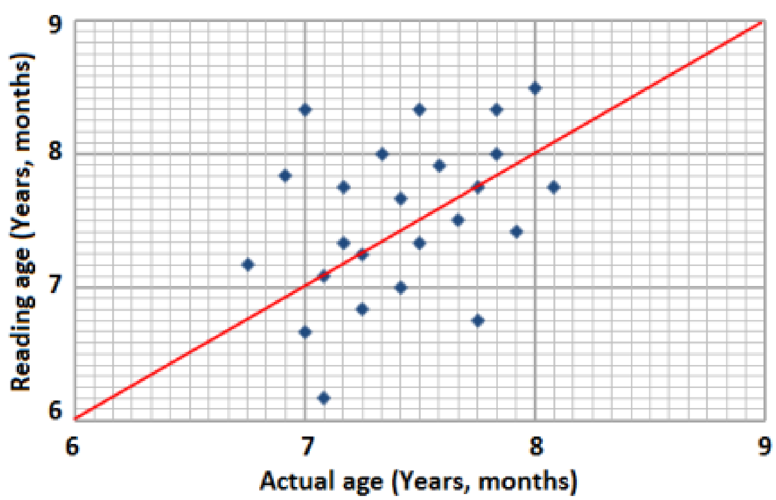
18. Using the Weekly Budget chart above, what is the person's annual salary? [Multiply weekly salary by 50.]
A) $42,000 B) $48,400 C) $51,456 D) %58,200

19. From the two charts above showing energy usage per month in a single home, which month had the highest total energy usage?
    A) August B) April C) July D) September

20. What is three point zero two five multiplied by two hundred?

21. A school day starts at 8: 50 with a ten-minute registration period. Before lunch, there are three lessons which are each fifty-five minutes and one fifteen-minute break. Lunch is one hour. What time does lunch finish?

The scatter graph below shows the actual age and reading age of 24 pupils.



22. How many pupils have a reading age higher than 7 years and 7 months?

	Time achieved in each training session in seconds				
Pupil	**Training 1**	**Training 2**	**Training 3**	**Training 4**	**Training 5**
A	66.3	65.9	65.7	67.0	66.5
B	68.2	68.0	68.1	69.0	68.1
C	65.3	65.1	64.9	64.7	64.5
D	67.8	67.1	68.6	68.2	66.9
E	65.5	65.7	66.0	66.2	66.3
F	66.8	66.5	66.4	66.1	65.8

23. What student, according to the chart above, showed a continual improvement in training?

24. Google maps has told Juanita that her car trip will be 32 miles. Juanita has already gone 14 miles. How fast, in miles per hour, must Juanita drive to arrive in 16 more minutes?

Questions 25-28 refer to the table below:

Exam	**SAT**		**ACT**	
Year	**2001**	**2006**	**2001**	**2006**
Alabama	9	9	69	79
Alaska	51	51	34	25
Arizona	34	32	28	18
Arkansas	6	5	75	75
California	51	49	12	14

Percentage of high school graduates in classes of 2001 and 2006 who took each test (some students took both exams):

25. More students from Arizona took the ACT than the SAT in 2006
True False Cannot Determine

26. In 2001, more Alaskan than Arizonan students took the ACT.
True False Cannot Determine

27. No more than 9% of the students from Alabama took both exams in 2001.
True False Cannot Determine

28. About 63% of California students took at least one of the exams in 2006.
True False Cannot Determine

29. If there are 6.3 billion people in the world now and the population increases at a (compounded) rate of 1.7% per year, how many billion people will there be in 26 years?

30. If you round 1.26735 to the nearest hundredth, what do you get?
A) 1.26 B) 1.27 C) 0.267 D) 1.267

31. 1.374 is closest in value to
A) 3/2 B) 10/6 C) 1.47 $0.0001374 \text{ X } 10^5$

32. Which would you prefer: $1,000 per year for each of the next five years, or the interest payment on a $2,000,000 loan, after 2 years at 2% annually?

IRS Tax Brackets for 2020

Tax Rate	Taxable Income (Single)	Taxable Income (Married Filing Jointly)
10%	Up to $9,875	Up to $19,750
12%	$9,876 to $40,125	$19,751 to $80,250
22%	$40,126 to $85,525	$80,251 to $171,050
24%	$85,526 to $163,300	$171,051 to $326,600
32%	$163,301 to $207,350	$326,601 to $414,700
35%	$207,351 to $518,400	$414,701 to $622,050
37%	Over $518,400	Over $622,050

33. Using the chart above, if you are single, earning $82,000, what amount of additional tax will you pay if your salary increases to $94,500 on Jan 1, 2020. The higher rate is paid only on the amount over the threshold limit.

34. Assume your grade in school is based on a “weighted average” which means that some items count more than others. In this scenario, quizzes count 30%, homework counts 20%, participation counts for 15% and tests and projects count for the remainder. Here are your scores to date: Quizzes (85.90.89), HW (100, 100, 70, 90), Participation (90), two tests (90, 94) and one project (96). What is your current score?

35. For your birthday, you want to fill the bathtub with magic water and soak in it. Magic water comes in 55-gallon drums only, which are 36” tall and 24” in diameter. Your bathtub is rectangular with measurements of 60” long, 18” deep and 24” wide. Which holds the greater volume of magic water?

APPENDIX D

FOCUS GROUP INTERVIEW QUESTIONS AND PROTOCOL

Focus Group Interview Protocol

1. Welcome the participants individually as they arrive and thank them individually for coming.
2. After the entire group has arrived, read the following statement:
   Thank you first and foremost, for being willing to participate in my action research project in Economics 203. The classroom portion of the project, known as the intervention, is complete, and you have provided me some valuable information through the past six weeks. Today, however, I am inviting you to participate in a more direct way, by participating in one of two focus group interviews. A focus group is a set of people with related experiences who will be given the opportunity to respond to various questions about the intervention in their/your own words. While you are not required to answer any or all of the questions, your responses will help me make better sense of what you considered important and effective about the lessons.
   Also in the room is an audio recorder, who will be recording the entire conversation so that I can replay it several times and gather themes and trends from it. This will form the basis for the conclusions to my research questions and will help me understand better how the intervention lessons affected you. No one, other than myself, will hear the recordings, and I will have the only copy of the recording. Your names will be coded as interview participants, and no one will know who is here and who said what. Having said that, I would encourage you to engage in open, honest dialog, so that I can use your feedback to make the instruction better for the next class. Thanks again for participating in the actual study and in todays' focus group.
   Before we begin, the closest restrooms for student use are located in the band wing, between Hurly and Campbell Auditoriums.
3. The rules for the focus group are quite simple, and I will explain them to you before we begin.
   I will ask 12 questions that have been prepared before the interview and approved. The questions are all open-ended, and any person may answer in any order after

4. the question is read. Please feel free to answer in whatever manner you choose, and also feel free to disagree with others or restate an opinion in your own words. My goal is to listen only and ask the next question when I feel it is time to go own. After we have moved to a new question, it is OK to go back and answer or add to a response from a previous question. I will answer your questions about the interview questions, or clarify the question for you if you ask, but I will do my best to refrain from guiding your responses.

   I know this is the hardest part for students, but you will not hurt my feelings if you comment in something you did not like. All learners are different, and you are closer to the target audience than I am, so please feel free to answer openly. The goal of this project is to make the lessons better for the students who come behind you, so this is a chance for you to help them.

   As a final note, you may also ask other people in the group to repeat or clarify their responses, and I may do so also if I don't hear the response completely. When asked, please don't take the questions as negative – they are meant to clarify and provide additional understanding.
5. Distribute consent forms for the Interview and read the following:

   I am handing you a formal consent form for the interview, although you have already consented to participate. By initialing each item, you are acknowledging that you understand how and why the data is collected, used and protected.

Student Consent Form for participation in a Focus Group interview at Suburban Regional High School on _________________________ (Date) at ________ (time) in _________________________ (location).

The interview was conducted by Mr. Bruce Thames, for the purpose of gaining student insight and feedback from the intervention lessons conducted as part of the Action Research Project entitled: Using Graphic Organizers and Spreadsheets to Increase Quantitative Literacy Skills in HS Economics Students

By initialing each item, I am acknowledging the item and its restrictions or provisions.

Item	Initials
1. I understand that my participation here is completely voluntary and I do not have to answer any question I decide not to answer.	___
2. I give my permission for this Focus Group Interview to be audio recorded to enable Mr. Thames to accurately transcribe and analyze the interaction and responses.	___
3. I understand that the person in the Room,_________________, audio recording and observing, is also bound to the rules of confidentiality that pertain to the Focus Group Interview.	___
4. I understand that my confidentiality is protected because my name will not appear anywhere in the research literature, reports to the school and does/will not affect my grade or good standing in Mr. Thames' classroom.	___
5. I am here today under my own free will, and no one has coerced me or made promises of any kind for my participation.	___
6. I will answer all the questions as best I can in order to promote learning and improved education for future students.	___
7. I understand that I cannot obtain a copy of this proceeding, nor will any copies of it be made available to persons other than Mr. Thames at any time now and in the future. At some point, after it is no longer needed for the purpose of this study it will be permanently deleted.	___
8. I may obtain a copy of the coded transcript after all names have been removed and may in fact be asked to clarify some point(s) I may have made during the interview.	___

Printed Name: _______________________________

Signed Name: _______________________________

Date: _____________________

Focus Group Open Ended Questions:

1. Tell me about your experience with the use of spreadsheet in this class?
    a) Was the use of the spreadsheet a help or hindrance to the lessons?
    b) Explain why?
2. Did you learn anything new, or of significant importance, from the use of the spreadsheets?
3. Overall, what were some of the important lessons you learned about numbers?
4. Can you give an example of something you might look at now and evaluate differently after the intervention?
5. Do you believe you can look at a chart or graph now and evaluate it correctly?
6. What kinds of things would you use to evaluate charts/graphs differently now than before the intervention?
7. Do you believe that you can explain what you learned to another student or coworker confidently?
8. Do you feel that you could engage in an academic discussion about charts and graphs in another setting with some confidence?
9. In which area of your future life do you believe this will be of most help?
10. What role did the graphic organizers play in helping you understand the data/processes?
11. Did the use of authentic data (specifically relevant to you as a student) change the way you learned – did it help you earn better or differently?
12. Overall, did the process we use in class help you learn the material better? If you could make one change or suggestion to the program, what would it be?

APPENDIX E

SAMPLE EXIT SLIPS

Exit Slip – Preintervention Lesson	Name:	Per:	Date:

1. What is the most important fact about spreadsheets you learned today?

2. On a scale of 1-5 (1 is Very Helpful, 5 is Added Confusion) how did the graphic organizer help you learn today?

1 Very Helpful	2 Added meaning	3 Neutral	4 Didn't use it	5 Added Confusion
O	O	O	O	O

3. Using the chart below, please write out the number for the anticipated Federal Tax Receipts for 2020?

Table S–1. Budget Totals [1]

(In billions of dollars and as a percent of GDP)

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Totals 2019–2023	Totals 2019–2028
Budget Totals in Billions of Dollars:														
Receipts	3,316	3,340	3,422	3,600	3,838	4,000	4,386	4,675	4,946	5,231	5,586	5,836	19,344	45,520
Outlays	3,982	4,216	4,407	4,206	4,734	4,941	5,160	5,346	5,526	5,746	5,985	6,181	23,855	52,612
Deficit	665	873	984	897	916	802	774	672	579	517	400	360	4,510	7,095
Debt held by the public	14,665	15,750	16,872	17,847	18,859	19,846	20,809	21,485	22,137	22,755	23,184	23,634		

4. Please write out the number 0.0345 as a percentage rounded to one decimal place.?

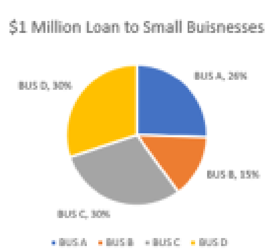
Exit Slip – Basic Chart Entry	Name:	Per:	Date:

1. What is the most important fact about pie or bar charts you learned today?

2. On a scale of 1-5 (1 is Very Helpful, 5 is Added Confusion) how did the graphic organizer help you learn today?

1 Very Helpful	2 Added meaning	3 Neutral	4 Didn't use it	5 Added Confusion
O	O	O	O	O

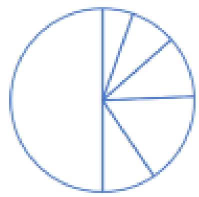
3. Using the pie chart to the left, did Businesses C and D receive the same amount of loan money from the government? If yes, explain your rationale. If no, please state how much difference in the loan amount could there have been for Companies C and D?



Exit Slip – Advanced Chart Entry	Name:	Per:	Date:

1. If you were showing a company's sales over a two year period, would you choose a pie chart, bar chart or grouped bar chart? Explain your choice?

2. In the pie chart shown below, what are two likely causes for the pie sector shapes?



3. On a pie chart, percentages are the best choice for data labels, but on a bar chart underlying numbers are best for display. Explain the rationale for the previous sentence.

4. Suggest one situation where a line chart might explain a concept better than a line chart?

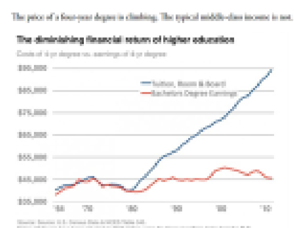
Exit Slip – Line Charts	Name:	Per:	Date:

1. What is the most important fact about line charts you learned today?

2. On a scale of 1-5 (1 is Very Helpful, 5 is Added Confusion) how did the graphic organizer help you learn today?

1 Very Helpful	2 Added meaning	3 Neutral	4 Didn't use it	5 Added Confusion
O	O	O	O	O

3. What are at least three sources of unproven or misleading claims, or graphical errors you can find in the line chart shown to the right?



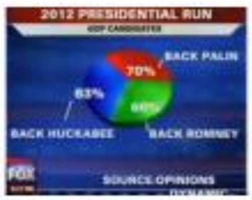
Exit Slip – Deciphering Charts	Name:	Per:	Date:

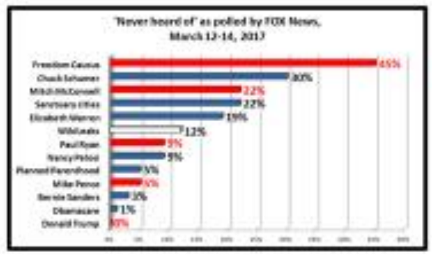
1. What are three ways that chart makers can deliberately mislead readers?

2. On a scale of 1-5 (1 is Very Helpful, 5 is Added Confusion) how did the graphic organizer help you learn today?

1 Very Helpful	2 Added meaning	3 Neutral	4 Didn't use it	5 Added Confusion
O	O	O	O	O

3. Find at least one error in each of the charts below?





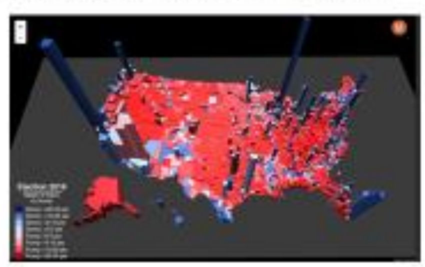
Exit Slip – Demographic Charts	Name:	Per:	Date:

1. What is a choropleth?

2. On a scale of 1-5 (1 is Very Helpful, 5 is Added Confusion) how did the graphic organizer help you learn today?

1 Very Helpful	2 Added meaning	3 Neutral	4 Didn't use it	5 Added Confusion
O	O	O	O	O

3. What additional information would you need to appropriately judge the accuracy of these graphs?



Exit Slip – Case Study	Name:	Per:	Date:

1. What did you learn from the case study that you did not know earlier about the reporting / available information on the COVID_19 pandemic?

2. Was the group interaction helpful for completing the case study? Could you have done it on your own, and if so with how much more time?

3. What do you believe are the two or three top facts that make a chart more reliable?

4. Has the work done in this study made you more aware of the necessity of looking at charts and graphs more critically? Please name one major item you will look out for in charts and graphs.

Exit Slip – Case Study	Name:	Per:	Date:

APPENDIX F

INTERVENTION LESSON PLANS

Intervention Lesson Plans

Pre-intervention lesson.

Standards:

- NJSLS 9.4.12.TL.: Assess digital tools based on features such as accessibility options, capacity and utilities for accomplishing a specific task.
- NJSLS 12.ASSE.B.3.a: Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

Objectives:

- Students will create basic spreadsheets using predetermined data with default settings and explain their findings about data entry in a graphic organizer.
- Students will manipulate data in the spreadsheets using basic data and formatting commands.
- Students will recognize how the spreadsheet formats data and displays precision of numbers and the impact both elements have on accuracy.
- Students will enter data into a spreadsheet, then edit and manipulate the data with no errors.

Description:

The pre-intervention lesson was conducted to ensure that participants have the basic skills necessary to construct, edit and analyze charts and graphs and their underlying data. Activities consisted of reviewing worksheet default settings, data entry, editing data for precision and clarity, basic formulas and how the differences between data, text, and cell formatting.

Activities:

1. Students will log in to Google Sheets and enter the data from a class handout. The data will vary in precision and type so that students will understand how the spreadsheets treats various textual and numeric entries.
2. Students will enter and copy specific functions to analyze data, including sums, averages, percent change, relation to the whole and relations to other numbers.
3. Students will edit data appearance by applying appropriate formats to specific data.
4. Students will make predictions about the effect of various data manipulations and test the predictions by performing specific operations on ranges of numbers.
5. Students will manipulate data to visualize how precision affects the results of calculations, despite the data's appearance in the sheet.
6. Students will label columns and rows of numbers and discuss the impact of data labels.

Unit 1 – Basic Charts and Graphs

Standards: All standards used are from the current New Jersey State Learning Standards (NJSLS,2020) unless otherwise indicated**.**

- NJSLS 12.ASSE.B.3.a: Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression
- NJSLS 9.4.12.CI.1: Demonstrate the ability to reflect, analyze and use creative skills and ideas.
- NJSLS 9.4.12.TL.1: Assess digital tools based on features such as accessibility options, capacities, and utility for accomplishing a specific task.
- NJSLS 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

Objectives:

- Students will create basic charts and graphs using a spreadsheet and simple data set and strengthen learning by completing a graphic organizer with lesson details.
- Students will be able to create appropriate charts or graphs given various data sets and requirements.
- Students will be able to change a chart type or modify a chart based on given requirements.
- Students will be able to distinguish between various types of numbers and symbols used in reporting economic data.

Description:

Graphs and charts are routinely used in economic instruction to show trends, relationships, and values. All charts and graphs share basic features and have both

appropriate and inappropriate uses. Students will learn how to create basic charts and graphs, then become familiar with all the elements of the chart/graphs and explain how the various components of the graphs may be manipulated to increase the usefulness of the graph. Finally, students will identify all the various types of charts and graphs available in Google Sheets and create a matrix comparing/contrasting the various type of graphs.

Activities:

1. Students will enter data from a given data set and create a basic chart from the data, while completing a graphic organizer which reinforces ideas learned from the process.
2. Students will relate the elements from the data set to the pie chart, identify the elements and default settings of the basic pie chart.
3. Students will edit the basic data set while the pie chart is displayed to see how changes are configured in the chart.
4. Students will edit the various components of the pie chart, including section editing, chart background editing and title/label editing.
5. Students will repeat steps 1-4 , using the same data, to create and edit a bar chart.
6. Students will add a second group of data and explain how each type of char handles the new data and why that is important.

Unit 2: Advanced Charts and Graphs.

Standards:

- NJSLS 9.4.12.CI.1: Demonstrate the ability to reflect, analyze and use creative skills and ideas.
- NJSLS 9.4.12.IML.2: Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of the information, in media, data or other resources.
- NJSLS 9.4.12.IML.3. Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
- NJSLS 9.4.12.TL.1: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specific task.
- NJSLS 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

Objectives:

- Students will be able to create appropriate charts or graphs given various data sets and requirements.
- Students will be able to change a chart type or modify a chart based on given requirements.
- Students will be able to identify chart features and how they might distort or enhance chart meaning and effectiveness.

Description:

Students will evaluate and manipulate predetermined charts and graphs and identify features about the graphs and how they affect meaning. Students will examine

concepts that affect chart persuasiveness and utility such as maximum/minimum number of data points, coloring, labeling, legends, and other factors in chart creation. Students will compare data presented in various types of charts and compere their effectiveness.

Activities:

1. Students will create a premade two group data set and create two separate pie charts from the two groups and compare the chart size, formatting and orientation.
2. Students will check the charts for veracity and applicability by answering questions on the graphic organizers concerning section values, applicability of labels and size comparisons.
3. Students will select one of the two charts and change the chart type to observe the effects of 3D and exploded pie charts and discuss the changes to chart clarity and effectiveness.
4. Students will select both data sets and create group bar charts and stacked bar charts from the same data and compare the two for clarity and effectiveness.
5. Students will compare the effectiveness of the charts, discuss the effects of scale choice on both axes and discuss effects of color choices for printing purposes.
6. Students will create a Pareto chart (data in ascending order) and its usefulness in chart effectiveness.

Unit 3: Line Charts

Standards:

- NJSLS 9.4.12.CI.1: Demonstrate the ability to reflect, analyze and use creative skills and ideas.
- NJSLS 9.4.12.IML.2: Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of the information, in media, data or other resources.
- NJSLS 9.4.12.IML.3. Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
- NJSLS 9.4.12.TL.1: Assess digital tools based on features such as accessibility options, capacities and utility for accomplishing a specific task.
- NJSLS 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

Objectives:

- Students will be able to create appropriate charts or graphs given various data sets and requirements.
- Students will be able to change a chart type or modify a chart based on given requirements.
- Students will be able to identify chart features and how they might distort or enhance chart meaning and effectiveness.

Description:

Students will use predetermined data to create line charts and then evaluate and manipulate them to understand how change to the chart format can alter/distort/clarify the

interpretations of line charts. Much of the daily economic data is presented in line chart format and students will be required to analyze the importance of both X and Y axis scaling, and their effect on chart interpretation and veracity.

1. **Activities:**
2. Students will use a premade data set to create a line chart and evaluate its usefulness.
3. Students will examine the chart to discuss positioning and display of data points, y-axis scaling and generation of line between data points.
4. Students will manipulate the line chart created in Step 1 to determine what editing features make the chart more understandable.
5. Students will retrieve line charts from the St Louis Federal Reserve (FRED) and evaluate them for meaning and clarity. Students will use their graphic organizers to annotate the effects of specific changes on the chart's effectiveness.
6. Students will evaluate charts showing the history of the Dow Jones Industrial Average (DJIA) using various editing techniques and discuss the benefits/drawbacks of each type of display.
7. Students will be asked to make interpolations of line charts by discussing activities that might occur between data points.
8. Students will be asked to make extrapolations of line charts by discussing activities that might extend beyond the final data point.

Unit 4: Deciphering Charts and Graphs.

Standards:

- NJSLS 9.4.12.IML.3. Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
- NJSLS 9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualization for an intended audience.
- NJSLS 9.4.12.IML.9: Evaluate media sources for points of view, bias and motivations.
- NJSLS 9.4.12.IML.10: Analyze the decisions creators make to reveal explicit and implicit messages within information and media.

Objectives:

- Students will identify all parts of a chart or graph and explain how to interpret and edit them.
- Students will be presented with charts and graphs showing the same data and choose the appropriate chart by completing a graph analysis form.
- Students will be given charts and graphs that are deliberately modified to distort data and be asked to identify the errors.
- Students will be given charts and graphs that are deliberately modified to distort data and be asked to correct the errors.

Description:

This unit discusses the area most likely to be problematic to students after high school. A significant number of graphs and charts either deliberately or carelessly display incorrect information. These students, like many others will make important

personal decisions about finances based on their interpretation of charts and graphs and need to be able to know when one is in error. This lesson will be primarily geared towards finding and portraying charts that produce incorrect or misleading data and giving students the tools to correctly analyze them.

Activities:

1. Students will be presented with a series of misleading charts and asked to work in teams to find and categorize the errors in them.
2. Students will be given specific data visualizations (charts made by graphic artists) and asked to compare them to authentic charts showing similar data.

Unit 5: Evaluating Demographic Charts and Graphs

Standards:

- NJSLS 9.4.12.IML.3. Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
- NJSLS 9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualization for an intended audience.
- NJSLS 9.4.12.IML.9: Evaluate media sources for points of view, bias and motivations.
- NJSLS 9.4.12.IML.10: Analyze the decisions creators make to reveal explicit and implicit messages within information and media.

Objectives:

- Students will identify all parts of a chart or graph and explain how to interpret and edit them.
- Students will be presented with charts and graphs showing the same data and choose the appropriate chart by completing a graph analysis form.
- Students will be given charts and graphs that are deliberately modified to distort data and be asked to identify the errors.
- Students will be given charts and graphs that are deliberately modified to distort data and be asked to correct the errors.

Description:

Students will examine various demographic maps, including voting participation, spending patterns and census data to determine their meanings accurately. Students will

examine various methods for highlighting and hiding data in charts and graphs and evaluate the effect of context on interpreting charts and graphs.

Activities:

1. Students will look at two basic PictoChart and assess their meaning as well as identify key factors in misleading charts.
2. Students will examine and interpret population pyramid charts and accurately assess its meaning by answering questions on a graphic organizer.
3. Students will examine a histogram showing scores on a completed assessment and accurately assess its meaning by answering questions on a graphic organizer.
4. Students will view the Census Bureau's 2000 Ancestry and Ethnic Origins Map and describe the individual county shading schemes by examining the underlying data.
5. Students will view two color maps of the 2016 presidential election and determine the shading schemes by evaluating underlying data.

Unit 6: Case Study: Examining the Veracity of Corona Virus Claims

Standards:

- NJSLS 9.4.12.CT.5: Participate in online strategy and planning sessions for course-based, school based or other project and determine the strategies that contribute to effective outcomes.
- NJSLS 9.1.12.G.2: Assess risks and benefits in various financial situations.
- NJSLS 9.4.12.IML.2: Evaluate digital sources for timeliness, accuracy, perspective, credibility of the source, and relevance of the information, in media, data or other resources.
- NJSLS 9.4.12.IML.3. Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions.
- NJSLS 9.4.12.IML.4: Assess and critique the appropriateness and impact of existing data visualization for an intended audience.
- NJSLS 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
- NJSLS 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.
- NJSLS 9.4.12.TL.4: Collaborate in online (group) learning communities or social networks or virtual worlds to analyze and propose a solution to a real-world problem.

Objectives:

- Students will work collaboratively to determine the veracity and accuracy of a series of charts and graphs presented during the COVID-19 virus pandemic in the Spring of 2020.
- Students will compare charts and graphs from the Spanish flu pandemic of 1920 and compare them to COVID-19 charts for effectiveness and utility.
- Students will work collaboratively to complete an assessment of the case study graphs and charts with a minimum acceptable score of 85%.
- Students will work collaboratively to identify key takeaways from the case study that would both identify shortcomings in their own learning experiences and assist future groups using the activity.

Description:

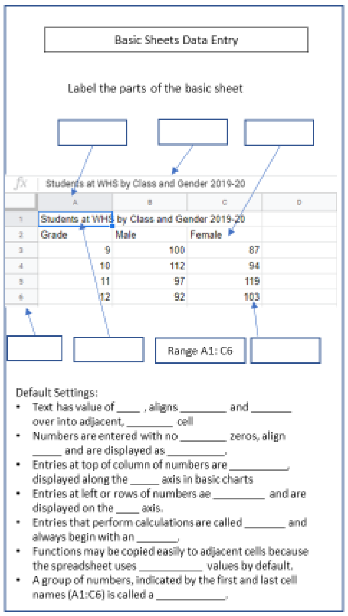
This lesson will involve the completion of a case study which requires the students to evaluate materials presented to them about information collected and presented during the COVID-19 crisis in 2020. The students will complete a graded graphic organizer that will require in depth examination of charts and graphs related to the corona virus pandemic. The students will be required to find flaws in the graphs and charts, prove veracity and discuss improvements to the effectiveness of the charts and graphs.

Activities:

1. Students will work in teams to interpret graphs and charts associated with the recent COVID-19 pandemic. Teams will interpret the intended meaning of charts and graphs, then discuss whether the data presented is accurate, meaningful and useful.

APPENDIX G

GRAPHIC ORGANIZERS FOR LESSONS
PREINTERVENTION GRAPHIC ORGANIZER


Basic Sheets Data Entry

Label the parts of the basic sheet

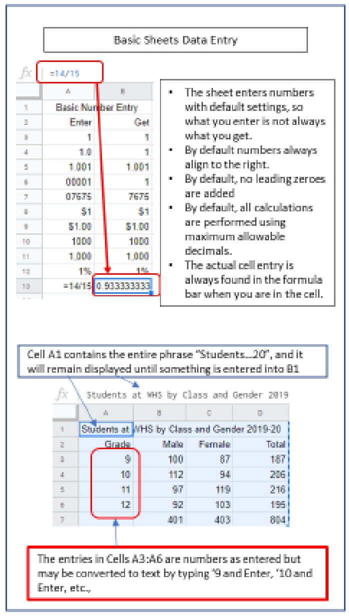
Students at WHS by Class and Gender 2019-20

	A	B	C	D
1	Students at WHS by Class and Gender 2019-20			
2	Grade	Male	Female	
3	9	100	87	
4	10	112	94	
5	11	97	119	
6	12	92	103	

Range A1: C6

Default Settings:

- Text has value of ____ , aligns ________ and _______ over into adjacent, ________ cell
- Numbers are entered with no ________ zeros, align ______ and are displayed as __________.
- Entries at top of column of numbers are __________, displayed along the _____ axis in basic charts
- Entries at left or rows of numbers ae _________ and are displayed on the ____ axis.
- Entries that perform calculations are called _______ and always begin with an _______.
- Functions may be copied easily to adjacent cells because the spreadsheet uses ___________ values by default.
- A group of numbers, indicated by the first and last cell names (A1:C6) is called a ____________.


Basic Sheets Data Entry

=14/15

	A	B
1	Basic Number Entry	
2	Enter	Get
3	1	1
4	1.0	1
5	1.001	1.001
6	00001	1
7	07675	7675
8	$1	$1
9	$1.00	$1.00
10	1000	1000
11	1,000	1,000
12	1%	1%
13	=14/15	0.933333333

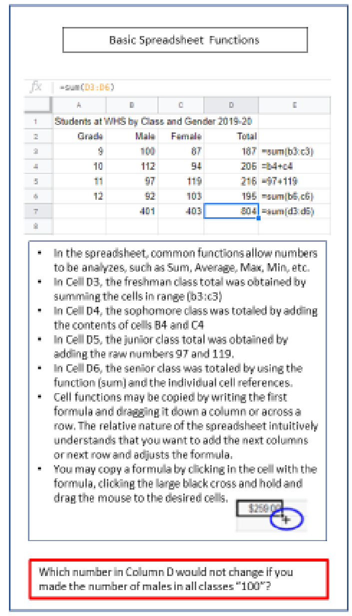
- The sheet enters numbers with default settings, so what you enter is not always what you get.
- By default numbers always align to the right.
- By default, no leading zeroes are added
- By default, all calculations are performed using maximum allowable decimals.
- The actual cell entry is always found in the formula bar when you are in the cell.

Cell A1 contains the entire phrase "Students…20", and it will remain displayed until something is entered into B1

Students at WHS by Class and Gender 2019

	A	B	C	D
1	Students at WHS by Class and Gender 2019-20			
2	Grade	Male	Female	Total
3	9	100	87	187
4	10	112	94	206
5	11	97	119	216
6	12	92	103	195
7		401	403	804

The entries in Cells A3:A6 are numbers as entered but may be converted to text by typing '9 and Enter, '10 and Enter, etc.,

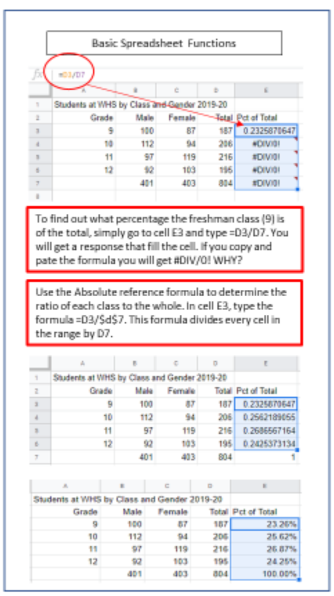

Basic Spreadsheet Functions

=sum(D3:D6)

	A	B	C	D	E
1	Students at WHS by Class and Gender 2019-20				
2	Grade	Male	Female	Total	
3	9	100	87	187	=sum(b3:c3)
4	10	112	94	206	=b4+c4
5	11	97	119	216	=97+119
6	12	92	103	195	=sum(b6,c6)
7		401	403	804	=sum(d3:d6)
8					

- In the spreadsheet, common functions allow numbers to be analyzes, such as Sum, Average, Max, Min, etc.
- In Cell D3, the freshman class total was obtained by summing the cells in range (b3:c3)
- In Cell D4, the sophomore class was totaled by adding the contents of cells B4 and C4
- In Cell D5, the junior class total was obtained by adding the raw numbers 97 and 119.
- In Cell D6, the senior class was totaled by using the function (sum) and the individual cell references.
- Cell functions may be copied by writing the first formula and dragging it down a column or across a row. The relative nature of the spreadsheet intuitively understands that you want to add the next columns or next row and adjusts the formula.
- You may copy a formula by clicking in the cell with the formula, clicking the large black cross and hold and drag the mouse to the desired cells.

Which number in Column D would not change if you made the number of males in all classes "100"?


Basic Spreadsheet Functions

=D3/D7

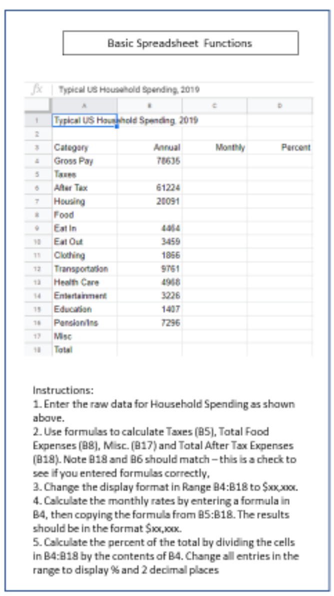
	A	B	C	D	E
1	Students at WHS by Class and Gender 2019-20				
2	Grade	Male	Female	Total	Pct of Total
3	9	100	87	187	0.2325870647
4	10	112	94	206	#DIV/0!
5	11	97	119	216	#DIV/0!
6	12	92	103	195	#DIV/0!
7		401	403	804	#DIV/0!
8					

To find out what percentage the freshman class (9) is of the total, simply go to cell E3 and type =D3/D7. You will get a response that fill the cell. If you copy and pate the formula you will get #DIV/0! WHY?

Use the Absolute reference formula to determine the ratio of each class to the whole. In cell E3, type the formula =D3/d7. This formula divides every cell in the range by D7.

	A	B	C	D	E
1	Students at WHS by Class and Gender 2019-20				
2	Grade	Male	Female	Total	Pct of Total
3	9	100	87	187	0.2325870647
4	10	112	94	206	0.2562189055
5	11	97	119	216	0.2686567164
6	12	92	103	195	0.2425373134
7		401	403	804	1

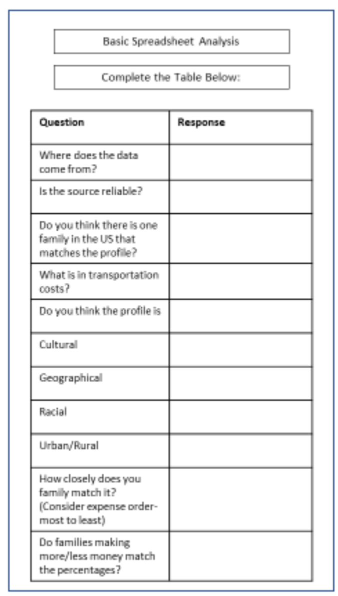
A	B	C	D	E
Students at WHS by Class and Gender 2019-20				
Grade	Male	Female	Total	Pct of Total
9	100	87	187	23.26%
10	112	94	206	25.62%
11	97	119	216	26.87%
12	92	103	195	24.25%
	401	403	804	100.00%


Basic Spreadsheet Functions

Typical US Household Spending, 2019

	A	B	C	D
1	Typical US Household Spending, 2019			
2				
3	Category	Annual	Monthly	Percent
4	Gross Pay	78635		
5	Taxes			
6	After Tax	61224		
7	Housing	20091		
8	Food			
9	Eat In	4464		
10	Eat Out	3459		
11	Clothing	1866		
12	Transportation	9761		
13	Health Care	4968		
14	Entertainment	3226		
15	Education	1407		
16	Pension/Ins	7296		
17	Misc			
18	Total			

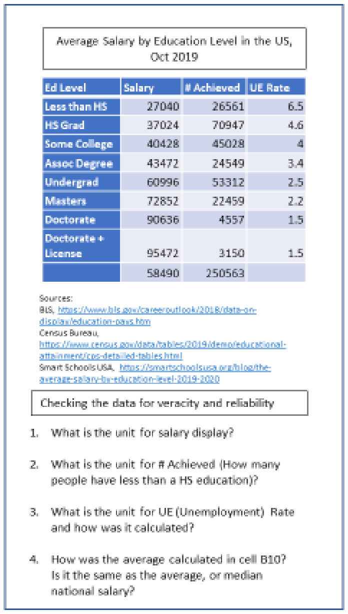
Instructions:
1. Enter the raw data for Household Spending as shown above.
2. Use formulas to calculate Taxes (B5), Total Food Expenses (B8), Misc. (B17) and Total After Tax Expenses (B18). Note B18 and B6 should match – this is a check to see if you entered formulas correctly,
3. Change the display format in Range B4:B18 to $xx,xxx.
4. Calculate the monthly rates by entering a formula in B4, then copying the formula from B5:B18. The results should be in the format $xx,xxx.
5. Calculate the percent of the total by dividing the cells in B4:B18 by the contents of B4. Change all entries in the range to display % and 2 decimal places


Basic Spreadsheet Analysis

Complete the Table Below:

Question	**Response**
Where does the data come from?	
Is the source reliable?	
Do you think there is one family in the US that matches the profile?	
What is in transportation costs?	
Do you think the profile is	
Cultural	
Geographical	
Racial	
Urban/Rural	
How closely does you family match it? (Consider expense order-most to least)	
Do families making more/less money match the percentages?	

UNIT 1 GRAPHIC ORGANIZER



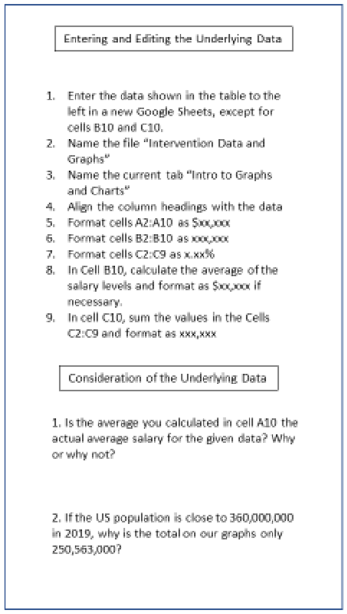
Average Salary by Education Level in the US, Oct 2019

Ed Level	Salary	# Achieved	UE Rate
Less than HS	27040	26561	6.5
HS Grad	37024	70947	4.6
Some College	40428	45028	4
Assoc Degree	43472	24549	3.4
Undergrad	60996	53312	2.5
Masters	72852	22459	2.2
Doctorate	90636	4557	1.5
Doctorate + License	95472	3150	1.5
	58490	250563	

Sources:
BLS, https://www.bls.gov/careeroutlook/2018/data-on-display/education-pays.htm
Census Bureau, https://www.census.gov/data/tables/2019/demo/educational-attainment/cps-detailed-tables.html
Smart Schools USA, https://smartschoolsusa.org/blog/the-average-salary-by-education-level-2019-2020

Checking the data for veracity and reliability

1. What is the unit for salary display?
2. What is the unit for # Achieved (How many people have less than a HS education)?
3. What is the unit for UE (Unemployment) Rate and how was it calculated?
4. How was the average calculated in cell B10? Is it the same as the average, or median national salary?



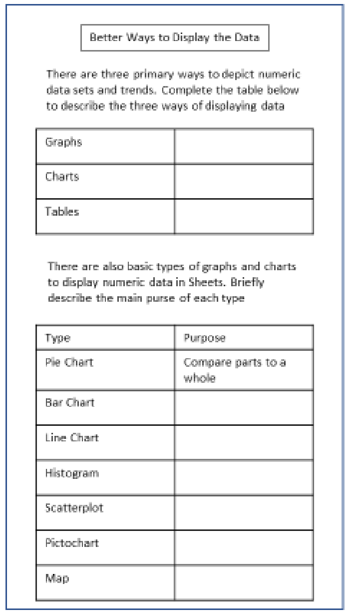
Entering and Editing the Underlying Data

1. Enter the data shown in the table to the left in a new Google Sheets, except for cells B10 and C10.
2. Name the file "Intervention Data and Graphs"
3. Name the current tab "Intro to Graphs and Charts"
4. Align the column headings with the data
5. Format cells A2:A10 as $xx,xxx
6. Format cells B2:B10 as xxx,xxx
7. Format cells C2:C9 as x.xx%
8. In Cell B10, calculate the average of the salary levels and format as $xx,xxx if necessary.
9. In cell C10, sum the values in the Cells C2:C9 and format as xxx,xxx

Consideration of the Underlying Data

1. Is the average you calculated in cell A10 the actual average salary for the given data? Why or why not?

2. If the US population is close to 360,000,000 in 2019, why is the total on our graphs only 250,563,000?



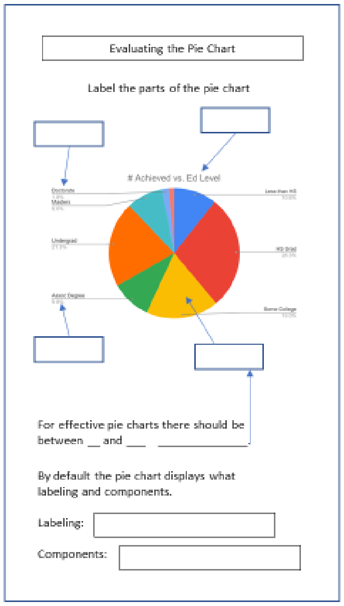
Better Ways to Display the Data

There are three primary ways to depict numeric data sets and trends. Complete the table below to describe the three ways of displaying data

Graphs	
Charts	
Tables	

There are also basic types of graphs and charts to display numeric data in Sheets. Briefly describe the main purse of each type

Type	Purpose
Pie Chart	Compare parts to a whole
Bar Chart	
Line Chart	
Histogram	
Scatterplot	
Pictochart	
Map	



Evaluating the Pie Chart

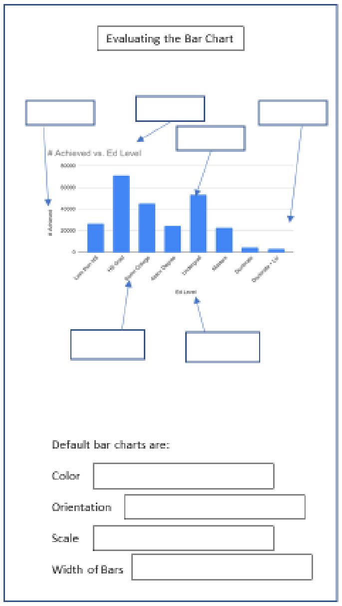
Label the parts of the pie chart

For effective pie charts there should be between __ and ___

By default the pie chart displays what labeling and components.

Labeling:

Components:



Evaluating the Bar Chart

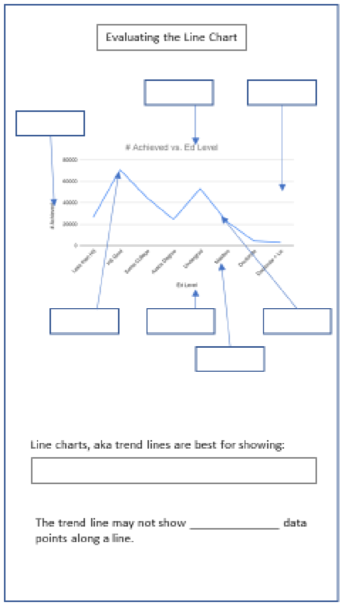
Default bar charts are:

Color

Orientation

Scale

Width of Bars

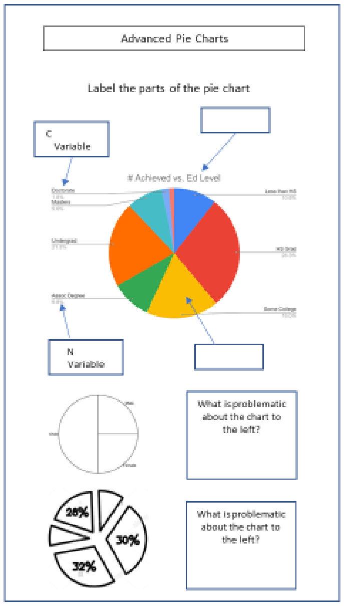


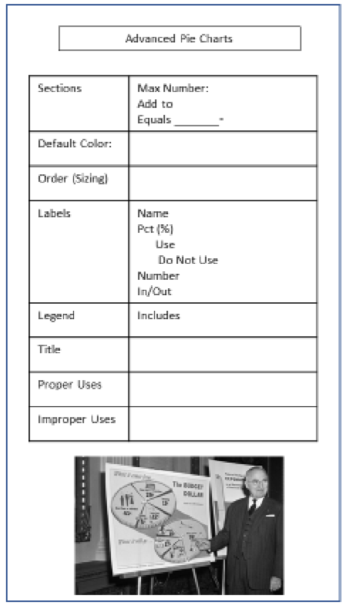
Evaluating the Line Chart

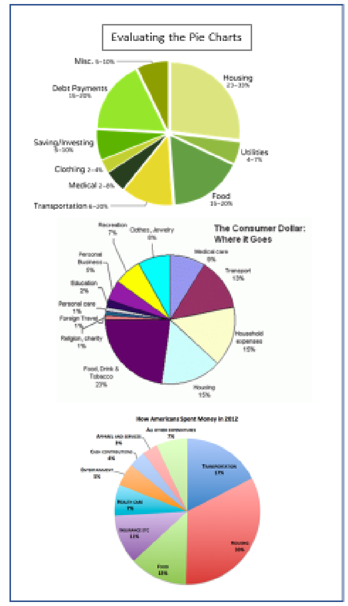
Line charts, aka trend lines are best for showing:

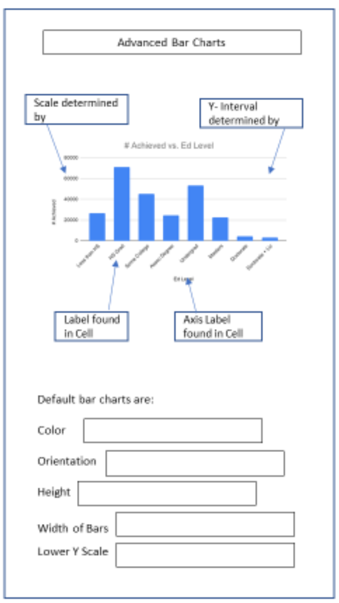
The trend line may not show ____________ data points along a line.

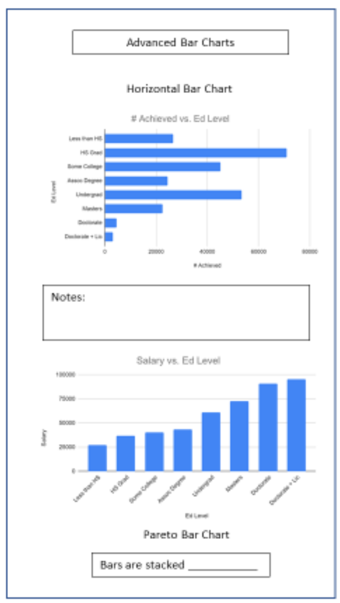
UNIT 2 GRAPHIC ORGANIZER

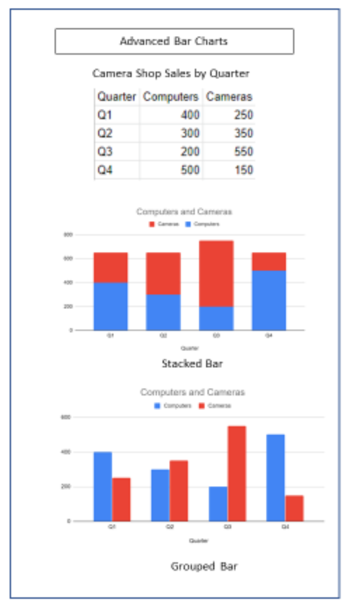








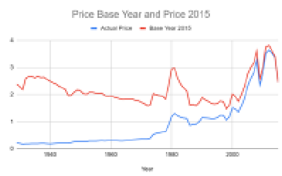




UNIT 3 GRAPHIC ORGANIZER

Advanced Line Charts

The chart below displays Real vs Nominal Retail Gas Prices from 1929-2015 (base year). The graphs plotted 88 actual data points to form the trend lines.

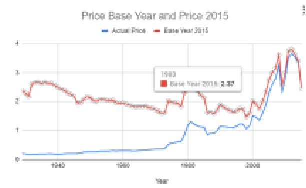


1. What is the Y-Axis scale based on?

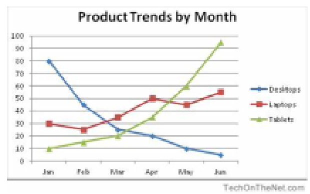
2. What is the Y-Axis scale based on?

3. Why are the x-axis displayed in decades and not years?

Advanced Line Charts

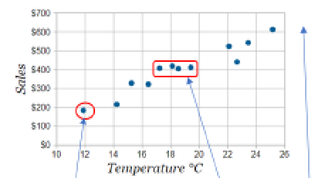


Notes: If you click on the trend line in Google Sheets you can see individual data point.



Notes: You can display data points to see actual data but trend lines are a______________.
What is the worst sales month? ____________

Advanced Line Charts



Is this one day's sales at 12° or more?

Does every day at these temperatures produce the same sales?

What happens at temperatures beyond 26°?

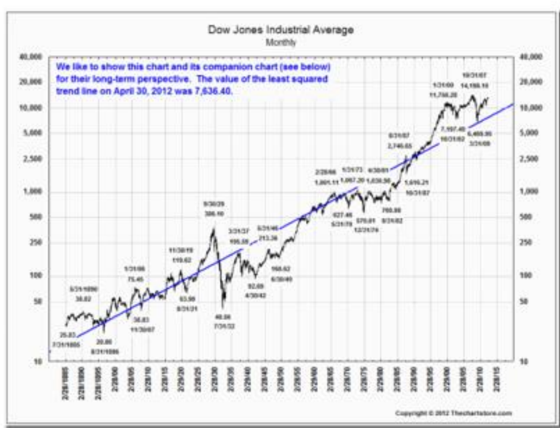
What does the chart actually prove or claim?

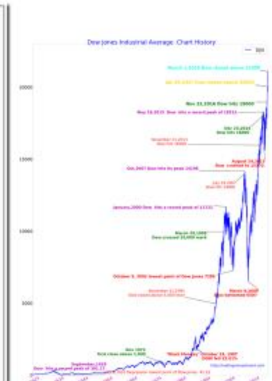
Assuming the data is correct, and it costs you $400 a day to operate, at what point would you open the store?

Advanced Line Charts

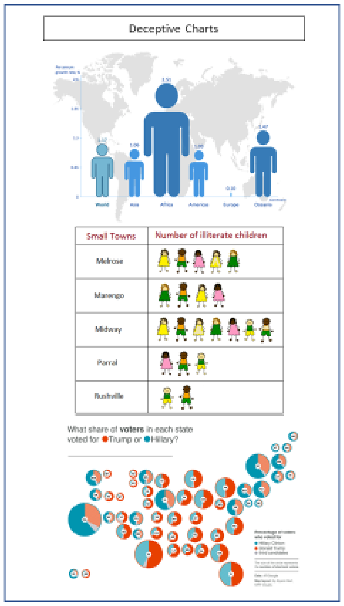
Identify major issues with the stock market trend charts.

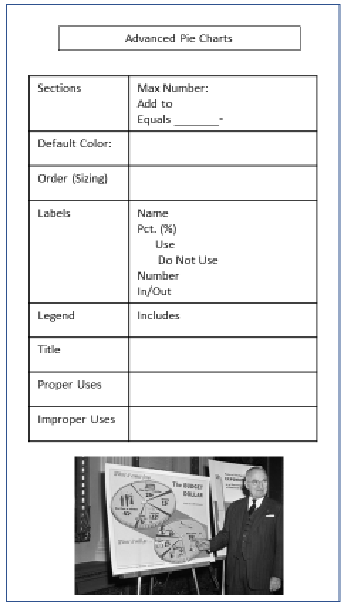
Which is more accurate?

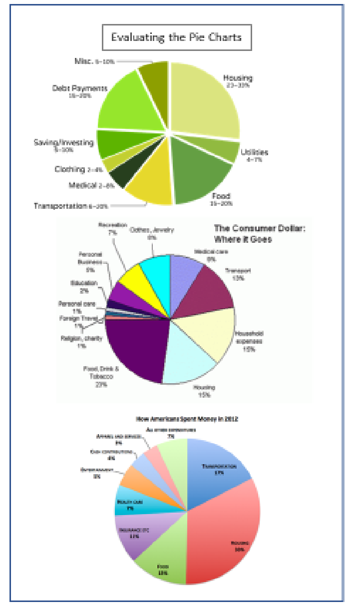


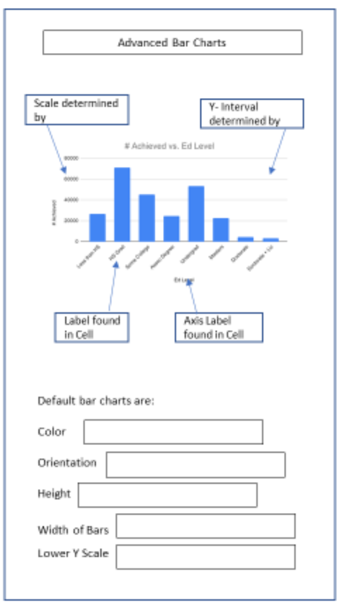


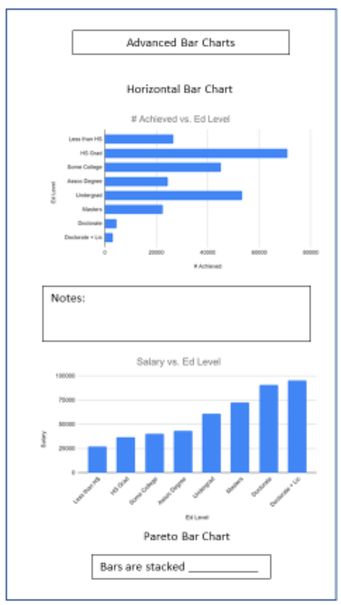
UNIT 4 GRAPHIC ORGANIZER

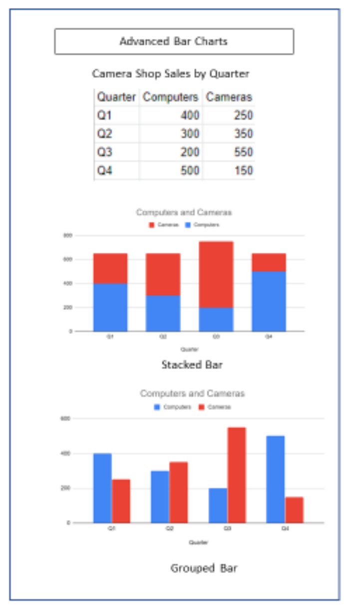






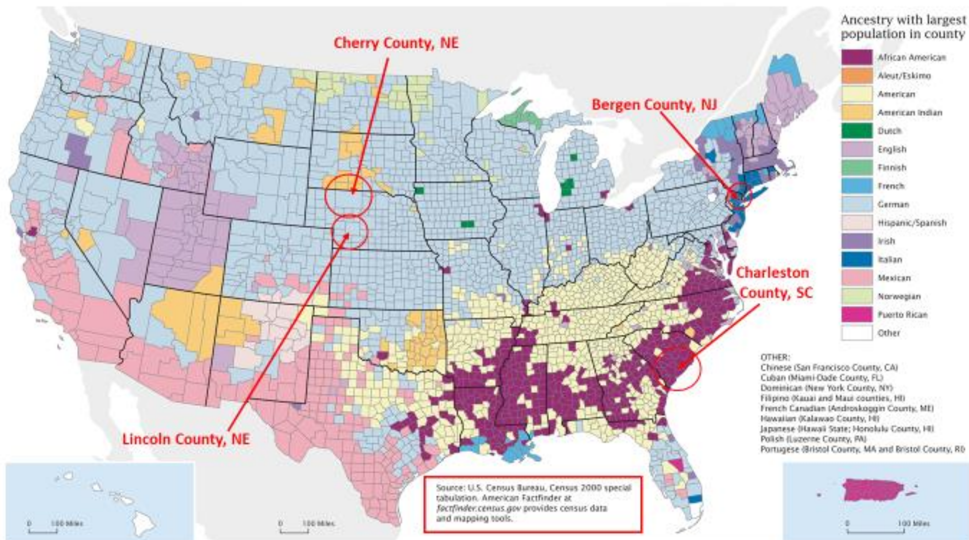






UNIT 5 GRAPHIC ORGANIZER

Choropleth Map Showing US Counties by Largest Reported Ancestry



Initial Map Analysis

What does "choropleth" mean?

What clues are available to determine the authenticity or veracity of the map?

Without prior knowledge, what is the primary ancestry group living in Cherry County, NE?

If the population of Cherry County, NE was 5,639 how many people of German ancestry might live in Cherry County ?

Find Charleston County, SC on the map and predict what ancestry is the main group in that county?

Based on your initial assessment, would you expect the population of Charleston County, SC to be predominantly black?

What might be the point of this map?

Advanced Map Analysis

Finding this data in a class period would be almost impossible, so link to the Cherry County, NE data here.

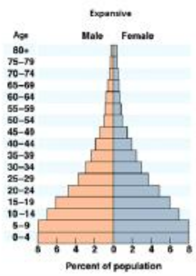
Cherry County, NE – 2000 Census Special Survey		
Race	Population	Percentage
White*		
Black		
NA		
Asian		
Other		
Ancestry	Population	Percentage
German		
English		
Irish		
American		
Hispanic		

Advanced Map Analysis

Finding this data in a class period would be almost impossible, so link to the Bergen County, NJ data here.

Bergen County, NJ – 2000 Census Special Survey		
Race	Population	Percentage
White*		
Black		
NA		
Asian		
Other		
Ancestry	Population	Percentage
Italian		
Irish		
German		
Polish		
Other		

Population Pyramids

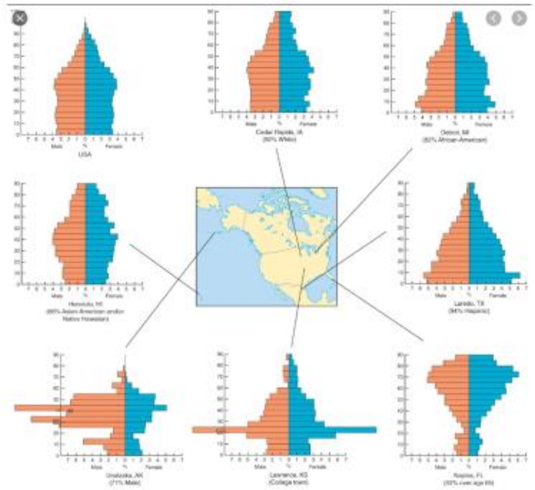


Purpose 1:

Purpose 2:

Type	Pop. Is	Type Nation	Fertility Rate	Life Expect
Expansive	Growing	Developing	Up	Down

Explain four of the eight population pyramids shown below



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Pictocharts

What does a "pictochart" display?

Advanced Map Analysis

Finding this data in a class period would be almost impossible, so link to the Cherry County, NE data here.

Cherry County, NE – 2000 Census Special Survey		
Race	Population	Percentage
White*		
Black		
NA		
Asian		
Other		
Ancestry	Population	Percentage
German		
English		
Irish		
American		
Hispanic		

Advanced Map Analysis

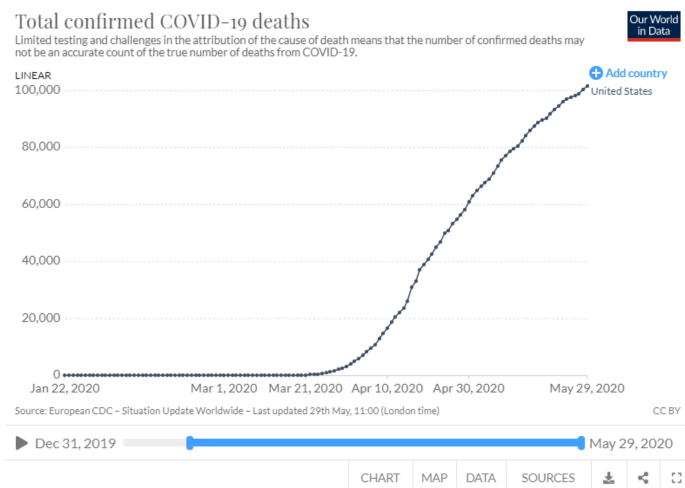
Finding this data in a class period would be almost impossible, so link to the Bergen County, NJ data here.

Bergen County, NJ – 2000 Census Special Survey		
Race	Population	Percentage
White*		
Black		
NA		
Asian		
Other		
Ancestry	Population	Percentage
Italian		
Irish		
German		
Polish		
Other		

APPENDIX H

INTERVENTION CASE STUDY

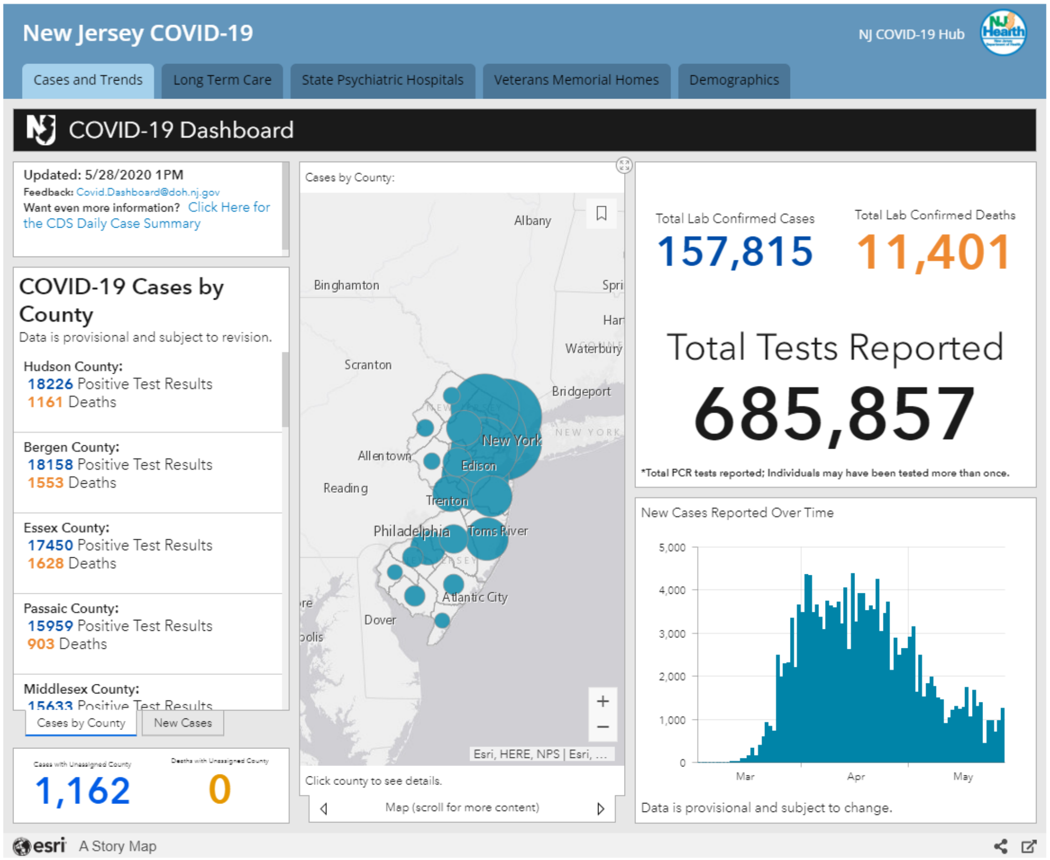
As of May 29, 2020, the US had over 100,000 deaths, in some ways related to the COVID-19 virus. The chart below shows the overall death toll from the virus as of 05/29/20.



Activity 1: Assess the validity and information available from the chart above.

Question	Response
What kind of chart is this and is it appropriate for the data it is supporting?	
What period of time does the chart cover?	
What can you assume about the start date?	
Do the axes scales seem reasonable based on the data?	
Can you verify the data?	
What are the individual data points on the chart?	
Is the Corona Virus death trend slowing, increasing or flattening?	
What additional data would you need to answer the question?	
What was the Corona Virus related death count on May 1, 2020? On May 15, 2020?	
Calculate the slope of the line between the two points and then state what the slop indicates.	

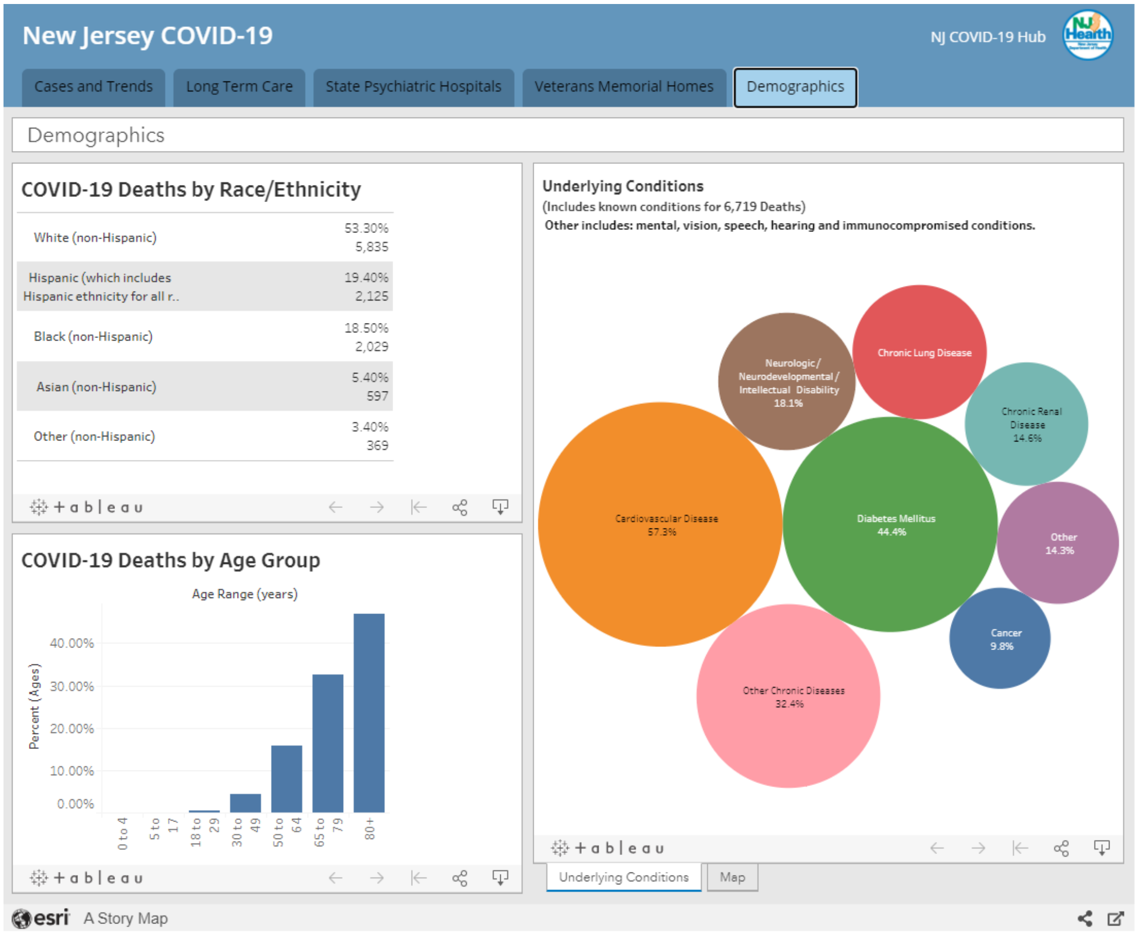
The State of NJ COVID-19 Dashboard for May 28, 2020 is shown below. Use the dashboard to answer the questions in Activity 2 below.



Activity 2: Assess the validity and information available from the chart above.

Question	Response
According to the map in the middle of the dashboard, what is the part of NJ with the most cases?	
How does your knowledge of the area geography confirm the accuracy of the data?	
According to the chart, "New Cases Reported Over Time", when did the number of cases peak?	
Which NJ County has the most deaths related to the Corona Virus?	
What is the percentage of deaths to reported cases in NJ as of 05/28/20?	
What information would you need in order to compare the NJ death/cases ratio to other states or to the U.S.?	

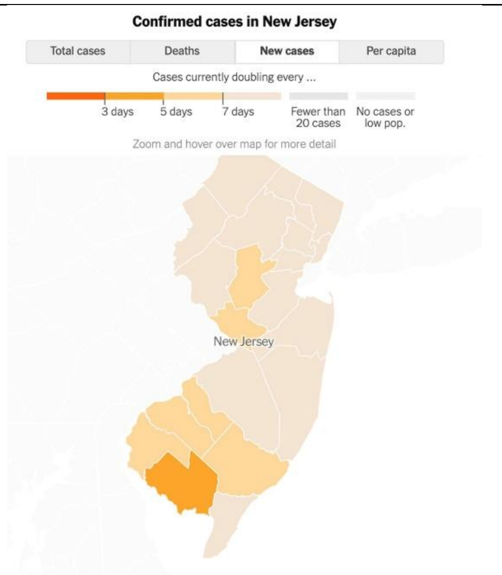
A second page of the NJ COVID-19 Dashboard reveals the following information. Complete the table in Activity 3 below the chart.



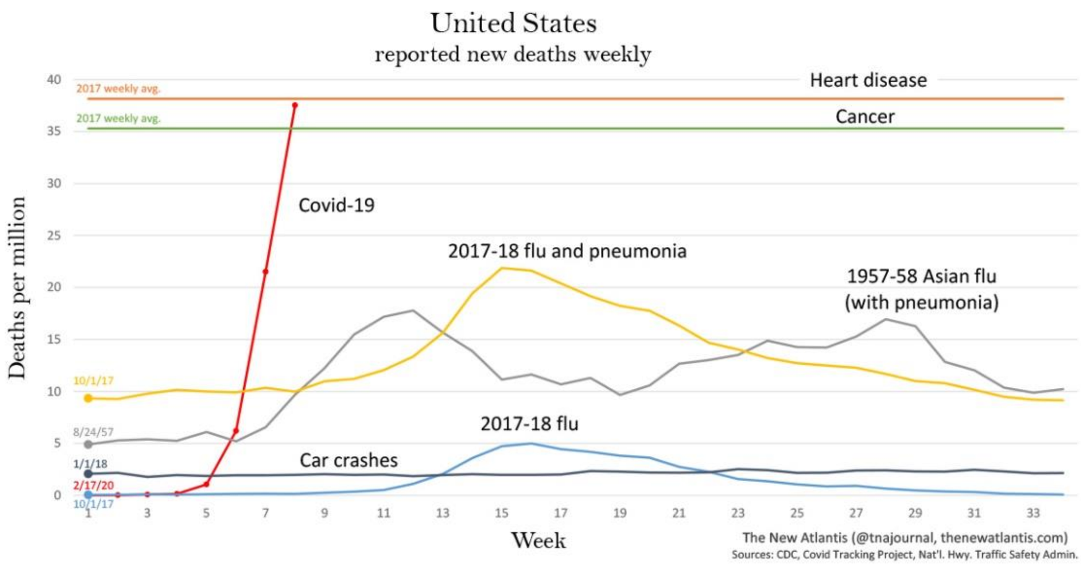
Activity 3: Assess the validity and information available from the chart above

Question	Response
What three types of data displays are used in the Dashboard, and what is their purpose?	
Chart 1	
Chart 2	
Chart 3	
Does the data in the Underlying Conditions chart reflect all of the NJ data?	
What would be the number of deaths with Diabetes as an underlying condition be for the chart? For the actual number?	
On the COVID-19 Deaths by Age Groups chart, might there be more than one reason for excluding information on deaths of those <18?	

The map below shows the number of reported cases that have doubled in NJ counties over various periods of time.

	Activity 4 If you look at the chart on Page 2, it shows that the number of cases in southern NJ are considerably smaller than the number of cases in northern NJ. Using the chart on the left, suggest at least two reason the cases are doubling faster in southern NJ. Reason 1 (Mathematical) Reason 2(Demographic or Geographic)

Use the chart below to answer questions about the COVID-19 pandemic.



Activity 5: Assess the validity and information available from the chart above

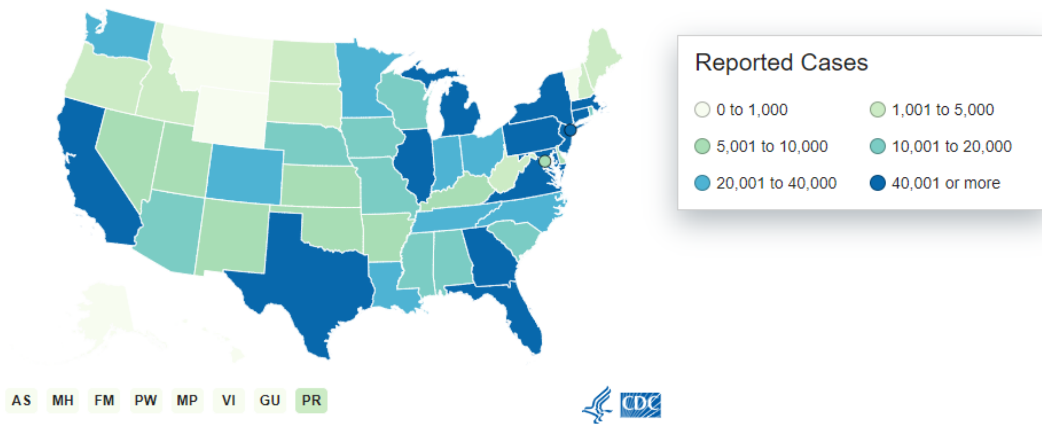
Question	Answer
What is the purpose of the chart above?	
Who published the chart and when?	
What information might be reasonably obtained from the chart above?	
When would Week 5 be for the 2017-18 flu? For the COVID-19 virus?	
The three flu epidemics on the charts peaked between weeks __ and ___?	
According to the chart, COVID-19 will pass Heart Disease as a cause of death by week _____?	
Why are the lines for Heart Diseases and Cancer straight lines, while all of the others are moving trends?	
If the population of the US is approximately 329,000,000 how many people would die from the Corona Virus in Week 7 of the virus according to the chart?	
How many more people succumbed to pneumonia than the flu alone in week 15 of the virus, if the population was 100,000,000?	

The choropleth map below shows Cases & Deaths by Jurisdictions (legal entity – state or territory). Analyze the map below by completing the table in Activity 5.

Cases & Deaths by Jurisdiction

31 jurisdictions report more than 10,000 cases of COVID-19.

This map shows COVID-19 cases and deaths reported by U.S. states, the District of Columbia, and other U.S.-affiliated jurisdictions. Hover over the map to see the number of cases and deaths reported in each jurisdiction. To go to a jurisdiction's health department website, click on the jurisdiction on the map.



Jurisdictions +

Activity 6: Assess the validity and information available from the chart above

Question	Response
How many states have Reported Cases between 5,001 and 10,000?	
Which state has the fewest Reported Cases?	
What is the minimum difference in Reported Cases between TX and LA?	
How many Reported Cases are in Washington, DC?	
What do the 3 states with fewer than 1000 Reported Cases have in common?	
In TX, where are the most Reported Cases? (Urban or Rural)	

APPENDIX I

BOARD APPROVAL TO CONDUCT STUDY

Westwood Regional School District
Office of Curriculum & Instruction
Jill Mortimer, Ed.D.
701 Ridgewood Road
Township of Washington, New Jersey 07676
201-664-0880

April 27, 2020

Dear Sir or Madam:

Mr. Bruce Thames, a teacher in the Westwood Regional School District, has periodically been in contact with me this school year regarding his intention to perform doctoral research in the 2020-2021 school year. I understand the title of his proposal is "Using Spreadsheets and Graphic Organizers to Increase Quantitative Literacy Skills." I support his research design, and I will bring his proposal to the Board of Education's Curriculum Committee for approval when they meet on May 8, 2020.

Feel free to contact me on my cell (201-359-6007) if you wish to discuss this further.

Sincerely,

Jill Mortimer, Ed.D.

APPENDIX J

PARTICIPANT INVITATION LETTER AND CONSENT FORM

Dear _____________,

My name is Bruce Thames, and I am a doctoral candidate in the Doctor of Education in Curriculum & Instruction — Educational Technology Concentration program in the College of Education at the University of South Carolina. I am conducting a research study as part of the requirements of my degree, and I would like to invite you to participate.

The purpose of this action research will be to gauge the effectiveness of using a spreadsheet, graphic organizers, and meaningful data to improve the quantitative literacy skills of high school juniors and seniors. Quantitative literacy is the practical application of learned math skills to everyday problems – financial literacy, comparing pieces of information while shopping for the best car deals, determining how much college really costs and correctly interpreting charts and graphs. It is estimated that less than 50% of US adults possess these skills, which may reduce their overall quality of life and financial success.

As a student participating in this research, you will be accomplishing several important goals. First you will be experiencing firsthand how academic research is conducted. Second, you will be providing valuable feedback to me about the effectiveness of the ideas I will be using to help you increase your quantitative, or mathematical, literacy skills, which will improve your personal future. Third, your feedback will help create and modify future classes that are more meaningful to the next students who take the course.

The research will be conducted in the fall semester of 2020, with some or all of the students enrolled in the US History II honors class. Students will be asked to participate, but participation is not mandatory. All students, whether they are participants or not, will be given the same instruction during the research intervention (specific lessons designed to focus on quantitative literacy skills), but only the confirmed participants will engage in the data collection activities for the research.

If you decide to participate, you will be asked to complete a survey in the first phase of the research, and complete exit slips at the end of each of the six intervention class periods. You may be asked to participate in a focus group interview after the research is completed. The initial survey includes some basic demographic survey information and questions about your technology usage and proficiency. At the end of the instructional period of the research (intervention), I will conduct a focus group interview, with selected participants, to get discussion on the research that helps explain the research intervention by providing student thoughts on the effectiveness of the intervention lessons.

You may feel uncomfortable answering some of the questions but be assured that all responses are confidential. You do not have to answer any questions that you do not wish to answer. The focus group interview will use pre-written questions with open ended responses. The interview will be audio recorded so that I can accurately transcribe what is discussed and listen to the comments more than once. The recording will only be reviewed by me and will be destroyed upon completion of the study.

Participation is confidential. Study information will be kept on a secure storage device maintained by the researcher. The results of the study may be published or presented at professional meetings, but your identity will not be revealed. In the report a pseudonym will be used to keep your identity confidential. At no point will anyone but me know the names, comments, feedback, or survey responses of any individual participant.

At no point during this process will participation affect the outcome of a student's performance in the US History II honors. Grading for the course is distinct from the research intervention, and participants will not receive a higher/lower grade based on their participation status.

I will be happy to answer any questions you have about the study. You may contact me at bruce.thames@wwrsd.org, or Dr. Arslan-Ari, my faculty advisor, at arslanai@mailbox.sc.edu. If you have any questions about the research confidentiality, please contact Dr. Jill Mortimer, Assistant Superintendent of the district at jill.mortimer@wwrsd.org.

Thank you for your consideration. If you would like to participate, please contact me in person after the research proposal has been presented in class during the second week of school. I will ask for all participants to participate in all phases of the research project. Thank you for agreeing to participate in my study.

My thanks for your participation,

Bruce A Thames
bruce.thames@wwrsd.org

I acknowledge that I have read and understand that by agreeing to participate in the research project “Using Graphic Organizers and Spreadsheets to Increase Quantitative Literacy Skills in HS Economics Students”, I am consenting to take part in various data collection activities, including:

- Completing a pre-intervention descriptive survey.
- Participating in six intervention classes and engaging in the quantitative literacy activities using spreadsheets and graphic organizers.
- Completing an exit slip (small 3-4 question assessment) after each intervention.
- Completing a non-graded, pre- and posttest assessment about my knowledge of qualitative literacy primarily involving charts and graphs.
- Participating in one of two focus group interview after the final intervention lessons to add personal, qualitative responses to help the researcher better understand the effectiveness of the research.
- Contribute in unplanned discussions to clarify earlier responses I made.

I further understand that I may withdraw from participation at any point in the process without fear of any adverse action resulting from my withdrawal. I also acknowledge that there are no financial or academic benefits given to me as a result of my participation.

I also understand that my privacy is important, and that the data collected from me and my identity will be kept confidential, known only to the researcher. If individual responses from any data collection is used, they will be kept confidential, with the participant identified by a pseudonym or a coded response. Finally, I understand that I may have access to the research document when it is completed and may ask the researcher questions about the process and conclusions, but not about individual responses.

Printed Name of Participant: ______________________________

Signature of Participant: _________________________________

Date: __________________________

If the particapnt named above is not 18 years old as of the start date of the research procedures, a parent or legal guardian is required to also give assent to participation. A student under 18 may not participate without an authorized signature.

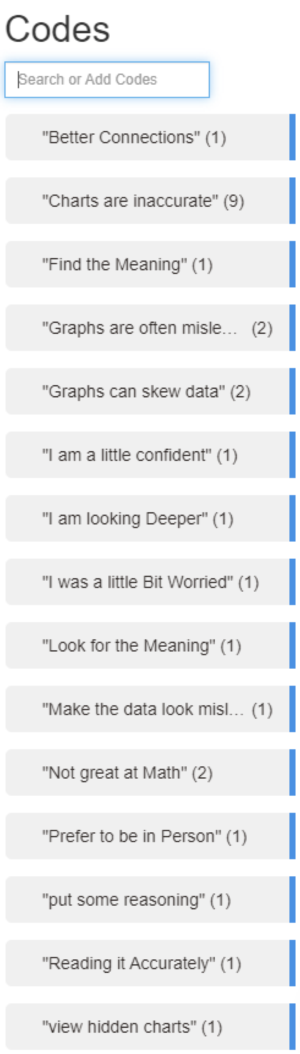
Printed Name of Parent of Legal Guardian: ____________________________

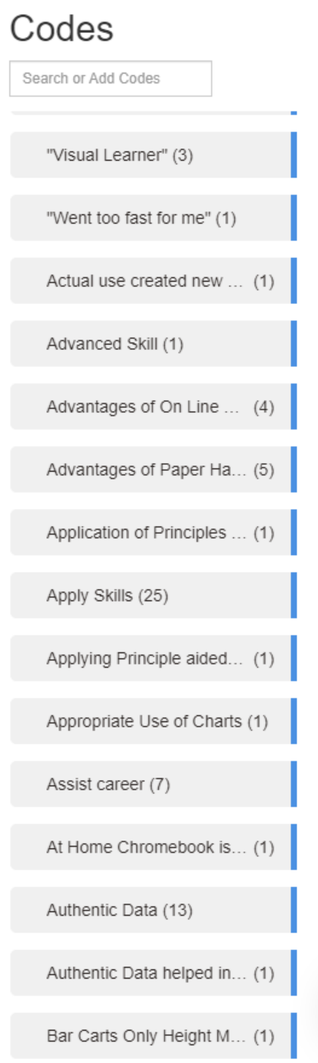
Signature of Parent or Legal Guardian:________________________________

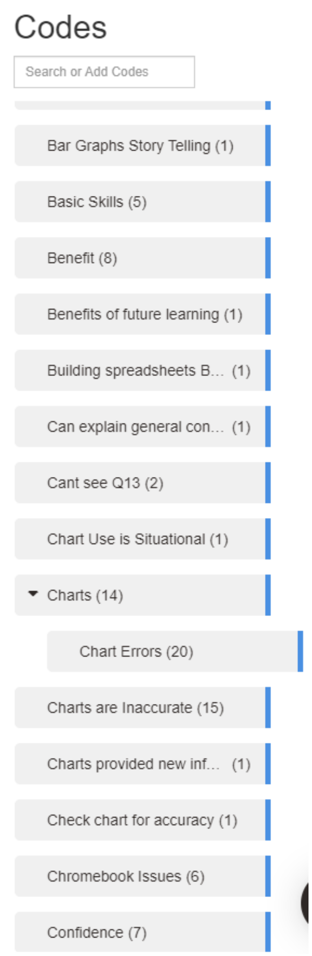
Date:______________________

APPENDIX K

LIST OF FIRST AND SECOND ROUND CODES IN DELVE TOOLS







Codes

Search or Add Codes

- Copying notes detracted… (1)
- Corona Virus Information (4)
- Couldn't be heard by class (1)
- Covid is dangerous in NJ (1)
- Creating charts and gra… (1)
- Creating Meaningful Ch… (1)
- Deception in Charts (1)
- Diabetes worsens coron… (1)
- Did not get all of the con… (1)
- Different Charts Reveal … (1)
- Disadvantages of On Line (1)
- Disadvantages of Paper (1)
- Discuss questions more … (1)
- Don't make assumptions (2)
- Early Confusion (3)

Codes

Search or Add Codes

- Engagement (1)
- Errors in Precision (1)
- Evaluating Charts helpe… (2)
- Explain Principles (5)
- Formulas (2)
- Formulas improved mat… (1)
- Good Process (1)
- Graph Creator tells a story (2)
- Graphic Organizer Diffic… (1)
- Graphic Organizers (9)
- Graphs Deliberately Misl… (6)
- Hidden Sheets (1)
- Higher Confidence whe… (1)
- History (3)
- Home PCS better than … (1)

Codes

Search or Add Codes

- Importance (1)
- Importance of formulas (1)
- Important to use different to…
- In Person learning better (1)
- In person with paper bet… (1)
- Increased Understanding (15)
- Leaned about Hidden C… (1)
- Learned ho to create a s… (1)
- Learning (1)
- Learning applies to all c… (1)
- Learning Spreadsheet is… (1)
- Lessons valuable for fut… (2)
- Limited Advanced Skills (4)
- Line Graph Positive Tre… (1)
- Line Graph Tracking Ch… (2)

Codes

Search or Add Codes

- Line Graph Uses (13)
- Line Graphs - Trends (1)
- Line Graphs Conparing ... (1)
- Line Graphs Data Points (1)
- Line Graphs Limited data (1)
- Line Graphs Quantities ... (1)
- Line Graphs Stories (1)
- Line Graphs Tracking C... (2)
- Line Graphs Trends (1)
- Look at Labels (1)
- Material learned is usefu... (1)
- Moving away from paper (1)
- Multiple ways of Learning (2)
- Must examine charts clo... (2)
- Must understand data u... (1)

Codes

Search or Add Codes

- Need technology skills (1)
- New Formulas (1)
- New Interests (1)
- New Knowledge (1)
- New Skills (22)
- New skills applied to mu... (1)
- New Strategy for Evalua... (1)
- New Ways of looking at ... (1)
- On Site Learning (2)
- On Site Learning Advant... (4)
- Opportunity to learn new... (1)
- Organization (1)
- Pace was a little fast (1)
- Pace was Fast (3)
- Paper better for learning (1)

Codes

Search or Add Codes

- Paper version would ha... (1)
- Pie Chart Deliberately M... (1)
- Pie Charts Are Inaccurate (1)
- Pie Charts Deliberately ... (3)
- Pie Charts Don't show al... (1)
- Pie Charts Important Le... (1)
- Pie Charts Inaccurate (3)
- Population Pyramid Ne... (1)
- Population Pyramids (1)
- Positive Spreadsheet ... (10)
- Problems (4)
- Proper se of numbers a... (1)
- Quantitative Literacy (7)
- Questions Not Addressed (1)
- Reliable Sources (1)

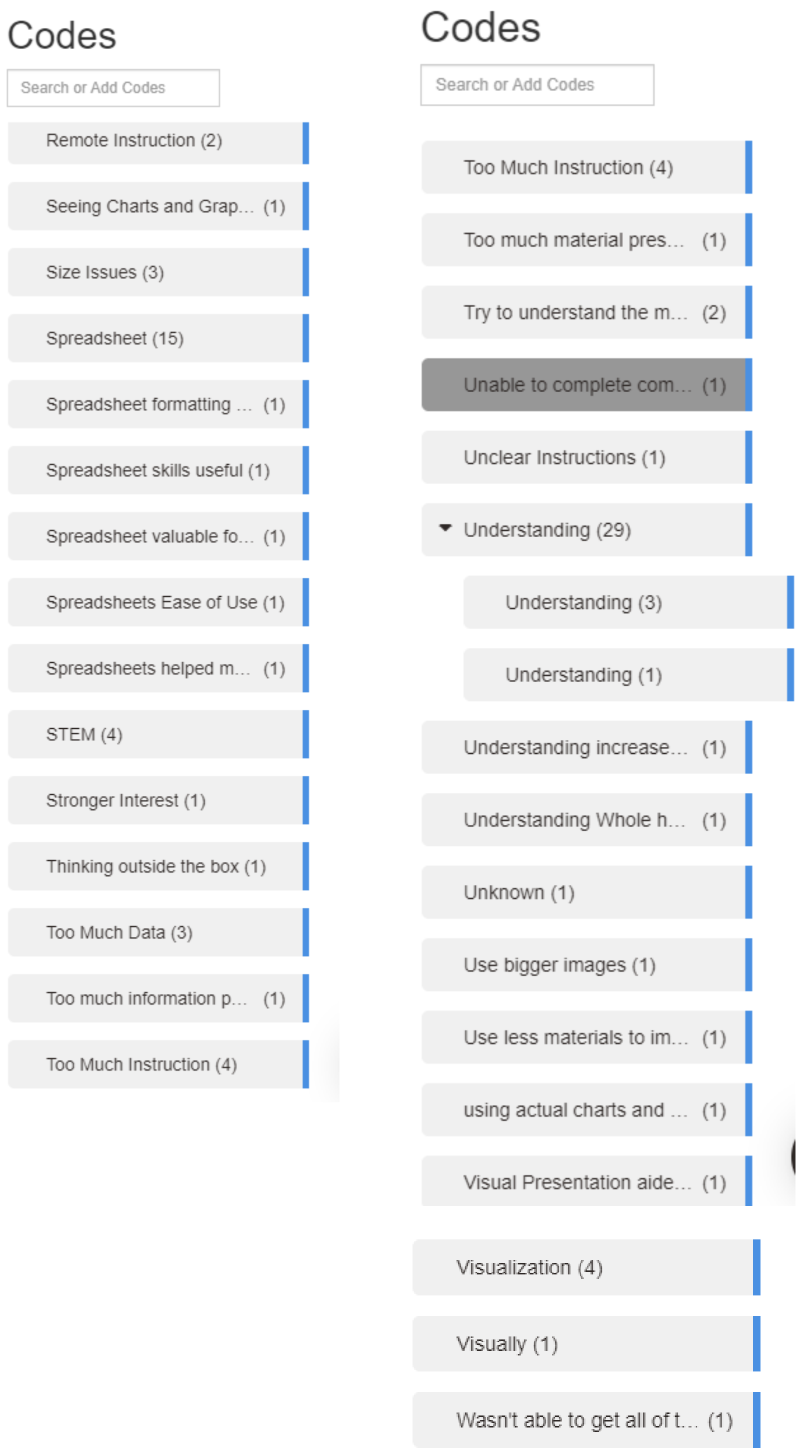


Figure L.1. List of All Codes in Delve Software.