THE EFFECTIVENESS OF A REVISED MIDDLE SCHOOL COMPUTER SCIENCE CURRICULUM ON STUDENT AND TEACHER EVALUATIONS

by

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DEDICATION

This dissertation is dedicated to my husband and sons. Blaine and Dylan Stratton, you are my inspiration. To my husband, Brian, your tireless support and dedication while I was on this journey kept our family together and for that, I will forever be grateful.

ABSTRACT

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The purpose of this quasi-experimental cohort study was to evaluate the effectiveness of a revised middle school computer science curriculum on teacher and student evaluations of the unit of study. Survey and focus group data were collected for this mixed-methods research design. The participants included two cohorts: 11 teachers and 527 students experiencing the original version and 26 teachers and 105 students experiencing the revised version. The findings showed teachers preferred the revised unit and students preferred the original. However, qualitative data showed teachers did not facilitate the original unit as written. Recommendations were to increase opportunities for student choice in the type of computer science artifacts they design and build and to provide curricular support for differentiation of content.

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CHAPTER I

INTRODUCTION

According to a White House press release, in 2015 there were more than 600,000 unfilled high-paying technology jobs across the United States, and by 2018, 51% of all STEM jobs are projected to be in computer science-related fields (The White House, Office of the Press Secretary, 2016). Although technology was central to the economy, science, and daily life, Wilson, Sudol, Stephenson, and Stehilk (2010) argued the U.S. has fallen behind in preparing students with "the fundamental computer science knowledge and skills they need for future success" (pg. 6). For example, government officials estimated just one-quarter of all K-12 schools in the United States offer high-quality computer science experiences for their students, and computer science courses count towards high school graduation in only 28 states (The White House, Office of the Press Secretary, 2016).

Compounding this issue, for the small percentage of schools offering high-quality computer science programs for their students, most of this exposure was happening as an elective at the high school level (Wilson et al., 2010). Unfortunately, once at the high school level, only a small percentage of students taking the courses were female and underrepresented minorities. In fact, a recent report from Gallup and Google (2015) found that although many students, parents, and K-12 educators valued computer science, most U.S. students did not have access to a computer science class at school. Researchers found that three in four principals surveyed reported their school did not offer computer science classes with programming or coding (Google-Gallup Partnership, 2015). According to the College Board (2016), in 2015 girls represented only 22% and underrepresented minorities only 13% of the approximately 50,000 students nationally who took the AP-Computer Science exam. The Computer Science Teachers Association (CSTA) advocated for early exposure to computer science and computational thinking to better prepare students for the workforce of the future, as positive exposure at a young age can increase lifelong engagement (Phillips, 2012). Additionally, Grover, Pea, and Cooper (2016) found "the middle school years are formative and key for cognitive and social development, especially with regard to future engagement with STEM fields" (para. 2). Therefore, developing a high-quality computer science curriculum for the middle school level was crucial to increasing student engagement in both STEM and computer science fields, as well as better preparing students to be effective problem solvers and computational thinkers.

In addition to the need to increase exposure at the middle school level, it was also imperative that students experience high quality and rigorous curriculum (Grover et al., 2016). With an ever-increasing amount of computer science curricula available to middle-level educators, a need existed to determine the quality and impact of emerging programs.

Statement of the Problem

The purpose of this research was to the evaluate the effectiveness of a revised middle school computer science curriculum on teacher and student evaluations of the course, including teacher evaluations of course quality and student evaluations of the student experience. The study also considered the differences between student and teacher assessments of the computer science unit of study. To address the increase in workforce demands for computer science-related positions, as well as to keep the U.S. competitive and innovative, students must have access to high-quality computer science education in primary and secondary school (Nager & Atkinson, 2016). Fluck et al. (2016) argued: "Computer science is rapidly becoming critical for generating new knowledge, and should be taught as a distinct subject or content area" (p. 38). The authors outlined three distinct rationales for offering computer science curricula, including economic, social, and cultural, as well as suggest two dimensions for evaluating the contribution of computer science:

> The first dimension is the beneficial context: the individual learner; the society in which they live; humanity and the ecology upon which we all depend; and the wider universe. The other dimension concerns the period for the benefits of the learning to be experienced: immediately; the lifetime of the individual learner; years within a social system transformation; the expected duration of humanity; or the lifetime of the universe. (p. 42)

These dimensions challenged curriculum writers to consider both the benefit to the individual and society when designing learning experiences. Specifically arguing for the inclusion of computer science education, Fluck et al. (2016) stated "not only is computer science heralding new developments in chemistry, physics, and biology, but data science is providing new methods for knowledge discovery" (p. 42). Many countries around the world have committed or initiated computer science as a subject including Australia, the United States, and the United Kingdom; additionally, several more countries were in the process of doing so including the Czech Republic, Denmark, Lithuania, Poland, and the Netherlands (Fluck et al., 2016). Although recently there has been wider adoption of middle school computer science curricula, Grover et al. (2016)

stated, a barrier to the implementation of high-quality computer science education is “the development of deeper, transferable computational thinking skills in the classroom setting is yet to be empirically validated” (para. 3). Webb et al. (2015) agreed that “defining a Computer Science appropriate curriculum structure and sequencing is challenging because there is less evidence of how students develop understanding of Computer Science compared with other subjects” (p. 64). Therefore, to add to the limited body of research regarding middle school computer science education, this study considered the effects of a middle school mobile application development unit of study on teacher evaluations of the course quality and student evaluations of the student experience.

Rationale

Computing and information technology have dramatically changed the way we work and live (National Research Council, Policy and Global Affairs, & Board on Global Science and Technology, 2012). Several stakeholders have called for an increase in computer science education for students in primary and secondary grades (Nager & Atkinson, 2016; PLTW, 2016; The White House, Office of the Press Secretary, 2016; Wilson et al., 2010). However, validated studies evaluating the effectiveness of available curricula for the middle school grades were lacking (Grover et al., 2016). Although significant gaps exist in K-12 computer science education (Wilson et al., 2010), researchers have found the U.S. school systems are adapting to a vision of students who are not just computer users but also computationally literate creators (Alano et al., 2016). This shift to students as creators, not merely users of computers, in the K-12 education landscape, was vital as the U.S. may face a labor shortage in the coming years with regards to computer science professionals. According to a White House press release, an additional 10,000 information technology and cybersecurity professionals were needed by the federal government, with the private sector needing even more (Office of the Press Secretary, 2016). The release stated, "providing access to CS is a critical step for ensuring that our nation remains competitive in the global economy and strengthens its cybersecurity" (2016, p. 1). Additionally, computer science was relevant outside the technology industry including education, financial, transportation, and healthcare. To this point, more than two-thirds of all technology-related jobs were outside of the technology sector (Office of the Press Secretary, 2016). The report *Searching for Computer Science* (Google-Gallup Partnership, 2015) contended:

> Rapid advancements in technology and the growing number of professions that rely on computer science make it crucial for all students to have opportunities to become computer literate and to gain foundational computer science skills, such as computational thinking and programming/coding. These skills encourage students to create and innovate, and position them to take advantage of the growing career opportunities that arise from attaining these skills. (p. 4)

The United States Bureau of Labor Statistics (BLS) (U.S. Bureau of Labor Statistics Office of Occupational Statistics and Employment Projections, 2015) estimated that employment in computer and mathematical occupations will increase by 12% between 2014 and 2024, generating more than 4.4 million jobs. The BLS (U.S. Bureau of Labor Statistics Office of Occupational Statistics and Employment Projections, 2015) stated this increase was due in part to "a greater emphasis on cloud computing, the collection and storage of big data, more everyday items becoming connected to the Internet in what is commonly referred to as the 'Internet of Things,' and the continued demand for mobile computing" (para. 1).

Research has shown "students with increased exposure to computer technology are more confident in their own skills and more likely to consider learning computer science in the future" (Google-Gallup Partnership, 2015, p. 7) thereby making computer technology a gateway to computer science learning. Nagar and Atkinson (2016) reported that schools offering computer science courses often "lack rigor or focus on computer use or just coding instead of delving into computer science principles" (p. 11). Likewise, Webb et al. (2015) contended:

> For many years national curricula, in many countries, have mainly focused on teaching basic computer skills such as word-processing, using email, drawing a graphics program, communication using Email and Chat and searching for information using the Internet and not the teaching of computational thinking which is a very important 21st century skill. A Computer Science curriculum would have this subject as its core and ensure all school pupils developed competence in it. (p. 64)

However, when done well, Nagar and Atkinson (2016) argued computer science is a major topic in education that can foster critical thinking, problem-solving, and creativity. Furthermore, Nagar and Atkinson (2016) stated: "computer skills and competencies are in high demand among employers in a wide range of industries, not just the tech industry" (p. 4). According to the writers of the K-12 Computer Science Framework (Alano et al., 2016):

> The power of computers stems from their ability to represent our physical reality as a virtual world and their capacity to follow instructions with which to manipulate that world. Ideas, images, and information can be translated into bits of data and processed by computers to create apps, animations, or autonomous

cars. The variety of instructions that a computer can follow makes it an engine of innovation that is limited only by our imagination. (p. 9)

The value of computer science in K-12 education went beyond technical knowledge and skills. As stated in the K-12 Computer Science Framework (Alano et al., 2016), instilling a solid foundation in computer science allows students to "go on to be computationally literate members of society who are not just consumers of technology but creators of it" (p. 11). Additionally, the principles of computer science and computational thinking, the "thought processes that are involved when solving complex problems and generalizing and transferring this problem solving process to a wide variety of problems" (p. 726) goes beyond programming and can be applied in a variety of settings when solving problems (Voogt, Fisser, Good, Mishra, & Yadav, 2015).

According to Grover et al. (2016), experience with computing in middle schools should make students open to the variety of opportunities available to them in the future. "Computer science plays a vital role in today's technology and globally connected world, which means that we need to introduce computing ideas to students early during their schooling years" (Yadav, Hong, & Stephenson, 2016, p. 565). Previous research (Grover et al., 2016) has shown that several factors influence learning of computer science by middle school students including "learners' prior experience, interests and attitudes towards the subject being taught in addition to academic preparation" (para. 14). Considerable gaps existed in the research for computer science education including a student's disposition for and attitudes toward computational thinking and computer science; Grover et al. (2016) suggested that researchers address this and other questions before computer science curricula may scale to schools across the nation.

One emerging provider of computer science curriculum, assessment, and professional development was Project Lead The Way (PLTW). PLTW was founded in 1997 and has grown from a high school engineering program for students in upstate New York to a national organization that includes a full K-12 offering for computer science, engineering, and biomedical science (Project Lead The Way, 2017a). PLTW is a 501(c)(3) nonprofit organization and as of the 2016-17 school year was implemented in over 11,000 schools in all 50 states, D.C., and U.S. territories (PLTW, 2017a). According to PLTW (2017a), in 2017 the organization impacted 2.4 million students and over 35,000 teachers. PLTW offers five distinct programs including Launch for elementary students, Gateway for middle school students, and three high school programs focused on computer science, engineering, and biomedical science. The most recent of these additions has been the computer science K-12 pathway established in 2014 with the development of the Advanced Placement aligned course, Computer Science Principles (PLTW, 2017a). Two nine-week computer science courses, entitled Introduction to Computer Science I & II (ICS I & II) were released in 2015 for grades seven through nine. In the fall of 2017, Project Lead The Way released two revised units to replace ICS I & II at the middle school level. A direct replacement of the mobile application development unit, ICS I, was entitled App Creators. Project Lead The Way (2017l) described App Creators as a unit that exposes "students to computer science as a means of computationally analyzing and developing solutions to authentic problems through mobile app development, and will convey the positive impact of the application of computer science to other disciplines and to society" (para. 6).

Past research has offered evidence that "PLTW contributes to raising achievement and motivation in science and engineering" (Tai, 2012, p. 6). In a 2013 study, Van

Overschelde found that of the study participants, “students who participated in PLTW were more prepared for higher education” (p. 10). Rethwisch (2014) reported on a longitudinal study to evaluate the impact of Project Lead The Way on student achievement outcomes in Iowa. This multi-year study tracked “multiple cohorts of PLTW participants and nonparticipants from 8^{th} grade into secondary education” (p. 1) and found statistically significant evidence that “PLTW increases mathematics or science scores on the Iowa Test of Educational Development by 5 points after controlling for selection bias” (p. 1). This increase in math score corresponded to about a half of a grade level (Rethwisch, 2014). Additionally, previous studies have shown that PLTW courses have positively influenced students’ decisions to study engineering as well as had a positive impact on students’ perceptions of technology (Voicheck, 2012). Moreover, Voicheck (2012) concluded: “that students believe the PLTW experience promoted their creativity and problem-solving abilities – skills which are crucial in their postsecondary studies” (p. 78). Students in the study noted that while mathematics and science courses specify one correct answer to a problem, PLTW courses encouraged students to find solutions their own way (Voicheck, 2012). Furthermore, Sorge (2014) concluded that “PLTW students were more likely to major in STEM compared to either of the non-PLTW student groups” (p. 107).

Unfortunately, the majority of past research has focused primarily on the PLTW high school engineering program, which created a gap in the research for both the middle school program and the PLTW computer science pathway. Research has shown the importance of introducing STEM-related subjects in early adolescence; for example, researchers found that about 70% of over 4,000 scientists and graduate students in the fields of chemistry and physics first became interested in science before high school (National Research Council, 2009). Additionally, Maltese and Tai (2010) stated:

> Encouragement is often seen as a means of fostering interest in a topic, but in this case it played a major role in sparking someone's initial interest in the topic. A common theme in science education is concerned with how to improve the training of science students; however, if one of the goals of science education is student persistence in STEM, it seems that teachers should focus on initiating interest and fostering engagement rather than on preparing for standardized examinations. This suggestion is not directed only to the grammar or middle school level educators—this should be the focus at all levels. (p. 682)

The impact of student engagement on student persistence in STEM is further supported as researchers reported that students preferred class activities that required them to collaborate with peers or were visually or physically engaging (Rowan-Kenyon, Swan, & Creager, 2012). Research has also shown the lack of full engagement is associated with higher rates of school stress, including physical symptoms of stress, and greater instances of cheating (Conner & Pope, 2013). The authors went on to suggest "that more interactive teaching, coupled with more relevant and rigorous curricula, might be effective antidotes to the prevalence of disengagement in secondary school" (Conner & Pope, 2013, p. 1427).

In the literature, student engagement has been described as a multifaceted construct which included three types of engagement: behavioral engagement, emotional engagement, and cognitive engagement (Fredricks, Blumenfeld, & Paris, 2004). Fredricks et al. (2004) defined these facets of engagement in the following way:

> *Behavioral engagement* draws on the idea of participation; it includes involvement in academic and social or extracurricular activities and is considered crucial for achieving positive academic outcomes and preventing dropping out. *Emotional engagement* encompasses positive and negative reactions to teachers, classmates, academics, and school and is presumed to create ties to an institution and influence willingness to do the work. Finally, *cognitive engagement* draws on the idea of investment; it incorporates thoughtfulness and willingness to exert the effort necessary to comprehend complex ideas and master difficult skills. (p. 60)

These three types of engagement illustrated the different ways students may feel connected to their work and their school. Although these types of engagement may be described separately, Fredricks et al. (2004) argued the fusion of the three categories provides a more complete characterization of student engagement than any one component is able in isolation.

According to Jarr, Vice President of Research and Program Effectiveness at Project Lead The Way, when creating student learning experiences, PLTW curriculum designers and developers make three conditions a priority: (1) Students are engaged in their own learning. (2) Students are empowered to solve relevant problems. (3) Students are confident and have the skills to tackle future challenges (Personal communication, February 3, 2017). The key condition of student engagement was defined by PLTW within the described construct of behavioral, emotional, and cognitive engagement. In addition to student engagement, curriculum development at PLTW was guided by six key drivers of student success. These drivers were called "PLTW Essentials" and included: Research-backed Instructional Philosophy, Relevant Curriculum Aligned with Industry and Postsecondary, Teachers Are Trained to Be Expert Facilitators, Engaging Content, Powerful Student Learning, and Meaningful Feedback and Assessment (Project Lead The Way, 2017m). Curriculum development at Project Lead The Way was driven by these PLTW Essentials (Jarr, personal communication, February 3, 2017). However, a comprehensive evaluation of the PLTW middle school computer science units had not been conducted using these PLTW Essentials. A portion of this study aimed to analyze teacher evaluations based on these PLTW Essentials to evaluate the quality of an original and revised middle school computer science unit of study focused on mobile application development. An additional component of the study looked at student engagement as evaluated by the students themselves to rate their behavioral, emotional, and cognitive engagement levels with the original and revised unit of study.

Research Questions

To determine the effects of a revised middle school mobile application development unit of study on student and teacher evaluations of a computer science unit of study the following research questions were addressed:

1. What effect did the revision of a middle school computer science unit of study have on teacher evaluations of course quality?
2. What effect did the revision of a middle school computer science unit of study have on student evaluations of student engagement?
3. What were the differences between student and teacher evaluations of a middle school computer science unit of study?

Description of Terms

Behavioral engagement. Fredricks et al. (2004) defined behavioral engagement as the level the individual participates in a given environment. In a school environment, behavioral engagement may be participation in academic, social, or extracurricular activities.

Cognitive engagement. Fredricks et al. (2004) defined cognitive engagement as the level of investment or willingness to exert the effort necessary to acquire new and complex knowledge and skills.

Computational Thinking (CT). Lee (2016) defined computational thinking as the human ability to formulate problems so their solutions can be represented as computational steps or algorithms to be executed by a computer.

Computer science. As defined by the ACM K-12 curriculum committee, computer science is the study of computers and algorithmic processes, including their principles, hardware and software designs, implementation, and impact on society (Tucker et al., 2006).

Emotional engagement. Fredricks et al. (2004) defined emotional engagement as encompassing "positive and negative reactions to teachers, classmates, academics, and school and is presumed to create ties to an institution and influence willingness to do the work" (p. 60).

Programming. Programming is described by the Massachusetts Department of Elementary and Secondary Education (2016) as the craft of analyzing problems and designing, writing, testing, and maintaining programs to solve them.

Project Lead The Way (PLTW). Project Lead The Way is a nonprofit organization that provides a transformative learning experience for K-12 students and teachers across the U.S. (Project Lead The Way, 2017a).

Contribution of the Study

This study would help inform stakeholders such as administrators, computer science educators, parents, and students about the quality of an available computer science curriculum for middle school students. Additionally, curriculum providers such as Project Lead The Way would benefit from this and similar studies to evaluate the effectiveness of revising units of study as assessed by students and teachers. Grover et al. (2016) stated that a barrier to the implementation of high-quality computer science education is that "the development of deeper, transferable computational thinking skills in the classroom setting is yet to be empirically validated" (para. 3). To address this gap in the research, this study measured the effectiveness of a revised middle school computer science curriculum on teacher and student evaluations of the course including teacher evaluations of course quality and student evaluations of the student experience. The study also considered the differences between student and teacher assessments of the computer science unit of study.

Process to Accomplish

This study was a quasi-experiment cohort study aimed to examine the effects of a revised middle school computer science unit of study. To address the first research question related to teacher evaluation of the unit, the researcher acquired historical data from the curriculum provider. The organization provided data from a survey administered to teachers across the country who facilitated either the original or revised version of a middle school computer science unit of study. The organization distributed the instrument through direct email to 1,000 middle school computer science teachers. The organization administered the survey for the original curriculum version during the spring semester of 2017 and again for the revised unit during the fall semester of 2017.

This instrument evaluated the curricula based on the established Essential Keys to Student Success as defined by the organization. The instrument assessed five factors related to course quality, including Powerful Student Learning, Research-Backed Instruction, Teachers Trained to be Expert Facilitators, Meaningful Feedback and Assessment, and Relevant Curriculum Aligned to Career and Post-Secondary Education. These factors were evaluated through a series of Likert-type survey questions, comparison questions, and open-ended response. In addition to the quantitative portion of the survey, Teachers were also asked to respond to questions related to changes they made to the content, changes they suggest PLTW make to the content, and any additional comments they would like to share with the organization. Additional data collected to address research question one included two focus groups consisting of six to eight teachers who had completed or were currently facilitating the middle school computer science courses. One focus group was held for individuals teaching the original version of the curriculum and once focus group took place for teachers using the revised curriculum. To analyze the first research question, an independent samples t-test was used to compare the teacher survey data as reported by teachers facilitating the original and updated versions of the curricula. Qualitative analysis measures were used to evaluate the focus group data collected from teachers facilitating the original and revised versions of the curricula as well as to analyze the open-ended questions within the survey instrument.

To address the second research question related to student evaluation of the unit, the researcher acquired historical data from the curriculum provider. The organization provided data from a survey administered to students across the country who experienced either the original or revised version of a middle school computer science unit of study.

The organization distributed the survey instrument to 8,000 students through an online survey link in the student portal where students access the course materials. The organization administered the questionnaire for the original curriculum version during the spring semester of 2017 and again for the revised version during the fall semester of 2017. The instrument evaluated three factors related to student engagement including cognitive engagement, emotional engagement, and behavioral engagement. These factors were assessed through a series of Likert-type survey questions, comparison questions, and open-ended response. Students were also asked to answer questions related to the benefits of taking the class, what they would change about the class, and what else they would like the organization to know. Additional data collected to address research question two included two focus groups consisting of six to eight students who had completed or were currently experiencing the middle school computer science courses. One focus group was held for students enrolled in the original version of the curriculum and one focus group took place for students enrolled in the revised instance of the curriculum. To analyze the second research question an independent samples t-test was used to compare the student survey data as reported by students participating in the original and revised versions of the unit of study. Qualitative analysis measures were used to evaluate the focus group data collected from students participating in the original and revised versions of the unit as well as to analyze the open-ended questions within the survey instrument.

To address research question three, the researcher analyzed the student and teacher survey and focus group data for the two versions of the course to identify if differences existed between the teacher and student evaluations of the middle school computer science units of study. To analyze the third research question, the researcher used a factorial ANOVA to determine if a difference existed between student and teacher evaluations of both the original and revised versions of the unit of study. Qualitative analysis measures were used to evaluate the focus group and open response data collected from students and teachers to analyze the differences between how each group evaluated the original and revised versions of the unit.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Although high-quality computer science education was vital in the efforts to keep the United States competitive and innovative in an increasingly technology-dependent world, just one-quarter of all K-12 schools offered computer science experiences for their students (The White House, Office of the Press Secretary, 2016). Several stakeholders called for an increase in computer science education for students in primary and secondary grades (Nager & Atkinson, 2016; Project Lead The Way, 2016; The White House, Office of the Press Secretary, 2016; Wilson, Sudol, Stephenson, & Stehilk, 2010). One emerging provider of computer science curriculum, assessment, and professional development was Project Lead The Way (PLTW). PLTW was founded in 1997 and grew from a high school engineering program for students in upstate New York to a national organization that included a full K-12 offering for computer science, engineering, and biomedical science (Project Lead The Way, 2017a). PLTW is a 501(c)(3) nonprofit organization and as of the 2016-17 school year was implemented in over 11,000 schools in all 50 states, Washington D.C., and U.S. territories (PLTW, 2017a). Two nine-week computer science courses, entitled Introduction to Computer Science I & II (ICS I & II) were released in 2015 for grades seven through nine. In the fall of 2017, PLTW released two revised units to replace ICS I & II at the middle school level. A direct replacement of the mobile application development unit, ICS I, was entitled App Creators.

In the literature, researchers and educational theorists proposed benefits of computer science education at the primary and secondary levels of formal education (Dekhane, Xu, & Tsoi, 2013; Papert, 1980; Papert, 2000; Wing, 2006). These included problem-solving, critical thinking, and computational thinking skills as well as empowering students to become creators of digital assets, not merely consumers. Organizations such as the Computer Science Teachers Association and researchers have argued for computer science as a core subject alongside mathematics and reading (Lee, 2016; Nager & Atkinson, 2016). Educators and researchers explored a variety of approaches to computer science education including mobile application development (Dekhane et al., 2013; Ernst & Clark, 2012; Johnson, Adams, Cummins, 2012; Mihci & Ozdener Donmez, 2017). Additionally, researchers described several reasons for and against using block-based visual programming languages in introductory computer science courses (Dekhane et al., 2013; Eid & Millham, 2012; Pokress & Veiga, 2013).

Grover, Pea, and Cooper (2016) highlighted several factors influencing the learning of computer science by middle school students including "learners' prior experience, interests and attitudes towards the subject being taught in addition to academic preparation" (para. 14). Considerable gaps existed in the research for computer science education including a student's disposition for and attitudes toward computational thinking and computer science. Grover et al. (2016) suggested researchers address this and other questions before computer science curricula may scale to schools across the nation. The aim of the current study was to evaluate the effectiveness of a revised middle school computer science curriculum on teacher and student evaluations of the course, including teacher evaluations of course quality and student evaluations of the student experience. The study also considered the relationship between student and teacher assessments of the computer science unit of study.

Historical Perspective

K-12 Computer Science Education

Historical perspective K-12 computer science education. The emergence of computer science as a discipline began in 1871 with Babbage's Analytical Engine programmed by Ada Lovelace as well as Gödel's 1931 incompleteness theorem. During World War II, the importance of computer science became more widely accepted and the first university-level course in computer science was offered at Cambridge in 1953 (Fluck et al., 2016). In the United States, Purdue University founded the first department of computer science in 1962. Since that time, computer science and information technology have filtered through and transformed almost every aspect of society including business and education (Fluck et al., 2016). Computer science became an academic discipline in the late 1960s and, as a focus of study, has had varying interest levels over the years (Nager & Atkinson, 2016). Although computer science has enjoyed a resurgence of interest in recent years, as early as 1980 Papert described the experience of programming and creating with computers as meaningful learning opportunities for young children. Papert (1980) proposed "When a child learns to program, the process of learning is transformed. It becomes more active and self-directed. In particular, the knowledge is acquired for a recognizable personal purpose. The child does something with it" (p. 21). Papert (2000) clarified his defense of the claim that students should program computers by expanding on the idea that "the ability to program would allow a student to learn and use powerful forms of probabilistic ideas" (p. 727). It is this use of problem-solving and empowerment that Papert claimed was the dominant force in learning and not exclusively the act of computer programming itself. Papert (1980, 2000) presented computer programming to make learning challenging, engaging, and meaningful in that it provided a constructivist approach to a variety of learning objectives and efficiently empowered students to construct meaning and build understanding. Furthermore, Papert found learning to code did more than simply expand a child's career options in the future; young students learned to understand, manipulate, and create digital assets. In addition to science and engineering fields, Dekhane et al. (2013) argued computer hardware and software were essential tools for business and liberal arts disciplines:

> To be successful in their academic studies and in their future career, today's students need to be able to adapt to a dynamic environment surrounded by new technologies. Thus, basic computer literacy is not enough to stay competitive in the current workforce. It has become essential that students develop a deeper understanding about computing and adequately apply computing skills, such as creating and manipulating digital graphics. More importantly, the problem solving skills and critical thinking ability developed and honed through the application of these computing skills are crucial to a student's future success in the face of constantly evolving technology regardless of their major. (p. 299)

According to Wing (2006), computational thinking was a fundamental skill not only for computer scientists but for everyone. Wing argued, in addition to reading, writing, and arithmetic, "we should add computational thinking to every child's analytical ability" (p. 33). Additionally, Wing (2006) found that children who built a strong foundation in computational thinking acquired domain-specific skills as well as built skills in problem-solving and critical thinking.

Present-day computer science educational landscape. Nager and Atkinson (2016) advocated for a shift in the positioning of computer science courses from a fringe, elective offering, to a core academic subject area. The authors contended, "Not only is computer science a powerful educational tool for fostering critical thinking, problem-solving, and creativity, computer skills, and competencies are in high demand among employers in a wide range of industries, not just the tech industry" (p. 1). Furthermore, in support of computer science education, the authors stated:

> Computer science challenges students and teaches them to approach problems in new and rigorous ways. If taught properly, computer science courses instill creativity, critical thinking skills, and logical reasoning. Its core concepts are broadly transferable, giving students the ability to apply skills to myriad problems, enabling them to pursue cross-disciplinary pursuits, and allowing them to learn about the world they live in. (p. 2)

Montoya (2017) maintained that job market needs and career readiness are not the only reasons computer science education must reach all students. By gaining a deeper understanding of computer science, students develop critical-thinking and problem-solving skills that are both in-demand and transportable to other disciplines. Furthermore, Montoya (2017) stated, "A lack of proper preparation and encouragement at the middle school and even elementary levels continues to result in a lack of interest in computer science programs further along in the education process" (p. 50). Therefore, supporting computer science education at the elementary and middle-level grades is a means to increase interest at the secondary and post-secondary levels.

Computational practices and concepts. As first described by Wing (2006), computational thinking is "reformulating a seemingly difficult problem into one we know how to solve, perhaps by reduction, embedding, transformation, or simulation" (p. 33). The elements of computational thinking as described by Angeli et al. (2016) included: abstraction, generalization, decomposition, algorithms including sequencing and flow of control, and debugging.

One approach to introducing computational thinking to students in the primary grades was to introduce the thinking process of computer science so students become competent to learn advanced topics related to theoretical and practical applications of computer science when they reach middle and high school (Angeli et al., 2016). Anglei et al. (2016) offered a framework for teaching computational thinking where students engaged in problem-solving by "developing a solution to a problem, automating the solution through algorithmic thinking, and generalizing this solution to new problems when common patterns are identified or recognized" (p. 50). Students may apply these computer science principles either using technology and computer programming or through unplugged experiences.

Mobile App Development with Visual Programming

The theoretical basis for visual programming as an educational tool. Visual programming has become increasingly popular as an introductory programming language, prompting researchers to compare the effectiveness of this approach to traditional procedural programming. Researchers have described several reasons for and against using block-based visual programming languages in introductory computer science courses (Dekhane et al., 2013; Eid & Millham, 2012; Pokress & Veiga, 2013). Eid and Millham (2012) described visual programming as a hands-on experience where students "manipulate visual concrete building blocks of a program, such as textboxes and buttons, and quickly produce an application" (p. 173). The researchers studied the performance of students in introductory programming classes who were introduced to either a console-based procedural programming environment or visual programming. Eid and Millham (2012) followed the progress of several classes of students, of up to 20 students per class, for several years to observe their performance in advanced, object-oriented visual programming. The test group consisted of students who, before their advanced programming class, had taken a class in console-based, procedural programming. Conversely, the control group consisted of students who, before their advanced programming class, completed an introductory object-oriented visual programming course. The students' average grade in the advanced course for the test group was compared with the control group. The data demonstrated students with a console-based procedural programming beginning course performed statistically better in an advanced programming course than their peers who experienced an introductory course with visual programming. The researchers concluded the students with a foundation in procedural programming were able to fully grasp basic programming concepts as compared to the group introduced to programming through a visual language. Eid and Millham (2012) concluded students accustomed to visual programming languages "have difficulty applying abstract programming concepts to the coding implementation of a visual programming application" thereby supporting the hypothesis that console-based procedural programming allowed students to rise to a higher level of cognitive development and think abstractly (p. 176).

Conversely, Dekhane et al. (2013) argued against teaching students the complexities and vocabulary of a text-based programming language. They contended:

> Due to the extensive amount of syntax required to create a computer program, students are left to memorize and accept traditional programming concepts without investment or engagement in the topics. As a result, students often do not recognize or appreciate the problem-solving opportunities within the software development process; students then become disengaged and thus tend to move towards other areas of study, causing a depletion of brain power and incoming fresh talent into the CS industry. (p. 300)

The authors advocated for the use of a visualized programming language for mobile application development as an engaging teaching methodology that allowed students to apply their knowledge to the real world. Using a visual programming language, students were able to test their program on mobile devices, received immediate feedback, and related this learning to their own lives. Dekhane et al. (2013) supported the use of visualized mobile programming tools as a vehicle to provide students the "opportunity to fully demonstrate their creativity in a structured environment where they are not completely hindered by their lack of programming knowledge" (p. 301). Another key benefit to visual programming and mobile application development is the product, or mobile app, which was developed by the student could be shared with other mobile device users, providing relevancy to the acquisition of new computer science knowledge and skills. Similarly, Pokress and Veiga (2013) stated:

It is surprising how strongly computer programming is associated with plain black and white text on a screen. App Inventor and other visual programming languages like it offer a solid, friendly, and rewarding entree into manipulating technological machines like mobile devices, robots, and PCs. (p. 3)

Finally, Klassen (2006) advocated for blocks-based visual programming over textual syntax due to the elimination of the need to memorize textural code constructs as well as avoid typing mistakes. This was especially advantageous for students whom English was a second language.

Mobile application development. The use of mobile technology has transformed how individuals work across all industries. Mihci and Ozdener Donmez (2017) predicted: "the novelty effect and the undeniable popularity of smart mobile devices may help achieve with today's young generation what the desktop computer revolution once achieved in the past" (p. 544). The development of mobile applications as a method for learning computer science is an example of an educational tool as described by Ernst and Clark (2012) "that creates student excitement and promote learner engagement while enhancing student competency" (p. 40). Johnson et al. (2012) found the innovation in mobile apps, including applications for creation and composition, make them relevant for teaching, learning, and creative inquiry.

Although using a visualized tool to introduce students to programming is not a novel idea, Dekhane et al. (2013) contended the development of mobile applications for this purpose is relatively new to computer science education. One reason for this recent development is that tools available to create mobile applications were complex and considered the realm of computer science professionals. However, tools emerged enabling non-professionals to create apps without extensive programming experience. According to Dekhane et al. (2013), the software used to create applications for mobile devices is robust and suitable for professional animators, game developers, as well as for academic purposes. The robust nature of the tools provided an opportunity for users to express their creativity, reduce the required level of programming expertise required, and helped to alter the student's focus towards critical thinking and problem-solving. The authors contended "the ease of creation of mobile apps, the visual impact and student interest in mobile apps are too significant for educators to ignore" (pp. 306-307).

Researchers Dekhane et al. (2013) looked at the role of mobile game development on student critical thinking and problem-solving skills in addition to the impact of mobile game development on student interest and sustained engagement in computing. The researchers had three goals when integrating the mobile app development software GameSalad into their Digital Media course. These included: "1) to leverage student interest in mobile technology and apps to enhance problem-solving skills and 2) to increase student engagement in a computing course by providing an active learning environment" (p.302). To evaluate the impact of mobile app development on student interest and engagement, the authors administered a Computing Attitudes survey at the end of each semester as well as a pre- and post-quiz designed to evaluate the problem-solving skills acquired by the students. The study included a total of 70 students in the fall semester of 2011, 65 students in the spring semester of 2012, and 70 students in the fall semester of 2012. For the second phase of the project, the researchers designed problem-solving assessments. Twenty-nine students participated in the pre- and post-quiz in the fall semester of 2012 and 28 students participated in the spring semester of

2013. In addition to the attitudes and problem-solving items, the survey and quiz included demographic information such as gender and age. The team assessed student engagement data to determine the perceived amount and quality of student-teacher interaction. Finally, the students provided feedback on the mobile application development experience. The pre- and post-quizzes were designed to evaluate students' problem-solving skills and required the students to complete a simple game on their tablet. The students also answered questions that required them to define the problem, create the solution, and plan test cases. After the study, the researchers found a significant difference between problem formulation, solution design, and test planning mean scores between the pre- and post-quizzes with the post-quiz being higher. In summary, the authors found positive leverage with the popularity of mobile devices and apps, combined with the interactive drag and drop format of the GameSalad software. Moreover, the students reported the mobile application development experience to be both fun and challenging and self-reported positive attitudes towards computing. The results demonstrated a visual game development tool such as GameSalad or MIT App Inventor could be used to significantly increase logical thinking and problem-solving skills among students. Additionally, the student-teacher engagement was reportedly higher as compared to other courses. Dekhane et al. (2013) concluded "the availability of other applications such as App Inventor and constantly improving mobile platforms and game creation software make mobile app development an attractive learning module to be included in the introductory computing curriculum" (p. 307).

Workforce Demands

Computing and computer-related skills have impacted all industries and the demand for skilled workers will only continue to grow (Nager & Atkinson, 2016). Unfortunately, of the projected 1.1 million computing-related jobs opening in the United States by 2024 only 45% of the openings will be filled by computing bachelor's degree recipients (National Center for Women and Information Technology, 2017). Moreover, individuals attaining Computer and Information Sciences bachelor's degrees do not reflect the population. For example, 57% of bachelor's degree recipients in 2015 were female; however, only 18% of Computer and Information Sciences bachelor's degree recipients were female in 2015 (National Center for Women and Information Technology, 2017). Due to the high value of graduates with technical knowledge and skills, Nager and Atkinson (2016) identified expanding intensive training in Computer Science and other STEM fields in high demand as an essential component of the United States' innovation policy. The authors argued the most important aspect of computer science is that it provides problem-solving skills and computational literacy, both of which are in high demand in the workforce. Computer science "ensures that students are competitive and adaptable in the labor market, not just for jobs in computer science, but for many occupations that increasingly require 'double-deep' skills" (Nager & Atkinson, 2016, p. 2). The Bureau of Labor Statistics projected the U.S. economy would grow to 161 million jobs over the 2012-2022 decade representing a growth of 10.8%. Computer and mathematical occupations were expected to grow faster than average yielding more than 1.3 million job openings at a rate of 18% (Richards & Terkanian, 2013). Of these occupations, software developers and programmers were estimated to account for 40% of new jobs created. Additionally, information security analysts were the fastest growing occupation in computer and mathematical occupations and were expected to grow at a rate of 36.5%.

The demand for software developers and programmers, as well as information security analysts, was driven by factors including an increase in demand for cybersecurity, an increase in the use of electronic medical records, and the prevalent use of mobile technology (Richards & Terkanian, 2013). In addition to workforce demands, the National Association of Colleges and Employers reported the highest average starting salaries for the Class of 2016 were earned by individuals who majored in the various computer science fields (Koc, Koncz, Tsang, Eismann, & Longenberger, 2017). These recent graduates reported an overall average starting salary of $71,916 which far exceeded the average salary for all graduates from the Class of 2016 who reported an average starting salary of $50,359. Computer science workforce demands extend to non-computer science professionals. Koc et al. (2017) stated: "demand for computer knowledge is ubiquitous, and transforms traditional sectors across the economy" (p. 4). The call for an increase in computer science education extended to the White House. In September 2017, President Donald J. Trump issued a memorandum for the Secretary of Education calling for a goal of $200 million in grant funding per year to promote high-quality science, technology, engineering, and mathematics education and Computer Science (The White House, Office of the Press Secretary, 2017). The rationale for this increase in access to high-quality STEM and Computer Science education was the administration's priority of equipping America's youth with the relevant knowledge and skills that lead to high-paying, stable jobs. With the expanding role of technology, the need to solve complex problems across industries, and improve lives around the world, the Trump Administration defined the need to train the future workforce to compete and excel in scientific and technical domains as critical. Similarly, Stanton et al. (2017) stated:

> There are simply not enough adequately trained people to fill the current need for information security analysts, hardware engineers, software developers, computer programmers, data scientists, and other STEM professionals. States must both inspire and prepare a far greater number of students to pursue CS education and related careers. (p. 7)

Although job opportunities related to science, technology, engineering, mathematics, and computer science are attractive and growing, many students in the United States did not have access to high-quality education in these fields. Access to computer science courses was especially rare. For example, 60% of high schools did not offer courses in computer programming in 2016. Minority and rural students had less access. According to a White House press release in 2017, "nationwide, only 34 percent of African American students and 30 percent of rural high school students have access to a Computer Science class" (para. 2). Access is also an issue for American girls. More than three-quarters of the students who took the AP-Computer Science A exam in 2016 were boys. Nationwide shortages in STEM and computer science teachers exacerbated this problem and President Trump called on the Department of Education to prioritize helping districts identify and train teachers in both the overall STEM subjects and particularly computer science (The White House, Office of the Press Secretary, 2017).

The authors of the 2017 State of the States Landscape Report emphasized the need to develop students' competencies in creating, not simply consuming, digital resources (Stanton et al.). Three key motives were outlined as the rationale to build these competencies in all students. The motives were as follows:

> Computer knowledge and skills are increasingly being recognized as foundational for an educated citizenry. CS is a central component of innovation, economic growth, and employment. The current homogeneity of the CS workforce constrains both opportunity and growth at the individual, state, and national levels. (p. 4)

Project Lead The Way

A leading provider of computer science curriculum, assessment, and professional development was PLTW. PLTW was founded in 1997 and has grown from a high school engineering program for students in upstate New York to a national organization that included a full K-12 offering for computer science, engineering, and biomedical science (Project Lead The Way, 2017a). PLTW is a 501(c)(3) nonprofit organization and, as of the 2016-17 school year, was implemented in over 11,000 schools in all 50 states, Washington D.C., and U.S. territories (PLTW, 2017a). According to PLTW (2017a), as of the 2017-18 school year, PLTW had trained over 55,000 teachers. PLTW offered five distinct programs including Launch for elementary students, Gateway for middle school students, and three high school programs focused on computer science, engineering, and biomedical science. The most recent of these additions has been the computer science K-12 pathway established in 2014 with the development of the Advanced Placement aligned course, Computer Science Principles (PLTW, 2017a). Two nine-week computer science courses, entitled Introduction to Computer Science I & II (ICS I & II) were released in 2015 for grades seven through nine. In the fall of 2017, PLTW released two revised units to replace ICS I & II at the middle school level. A direct replacement of the mobile application development unit, ICS I, was entitled App Creators. Project Lead The Way (2017g) described App Creators as a unit that exposed "students to computer science as a means of computationally analyzing and developing solutions to authentic problems through mobile app development, and will convey the positive impact of the application of computer science to other disciplines and to society" (para. 6).

Past research has offered evidence that "PLTW contributes to raising achievement and motivation in science and engineering" (Tai, 2012, p. 6). One study found "students developed teamwork skills, critical-thinking and communication skills, questioning and problem-solving skills" (Stohlmann, Moore, McClelland, & Roehrig, 2011, p. 34). PLTW's program for students in middle school, grades six through eight, offered ten units designed to "empower students to lead their own discovery" (Project Lead The Way, 2017g, para. 2). PLTW designed the Gateway middle school program as independent, nine-week units and assumed a 45-minute class period. In a comprehensive review of available literature, Tai (2012) found a robust and positive impact on science and mathematics achievement by PLTW as well as indications the program had an encouraging influence on students' likelihood to continue their education and on career interests. Additionally, a study by Pike and Robbins (2014) showed that PLTW high school graduates are nearly three times as likely to major in science, technology, engineering, and mathematics versus non-PLTW graduates.

Teacher Evaluations of Course Quality

Course Quality

Project Lead The Way Curriculum Theory of Action. Project Lead The Way (2017f) described curriculum development that led to near-term and long-term positive outcomes for students participating in PLTW programs. The organization stated, "that as a direct outcome, all students who participate in a PLTW learning experience will acquire problem-solving and process-thinking skills, technical knowledge and skills, and communication and professional skills necessary to thrive in an evolving world" (p. 1). Furthermore, the acquisition of these skills will have long-term and enduring impacts on the students because they will "be empowered for long-term success in life and career; prepare not just for specific jobs, but for all other roles they will have throughout their lives; and build skills over time and throughout their life" (p. 1). Additionally, the organization set three key conditions the learning experiences must meet. These included: "1) Students are engaged in their own learning. 2) Students are empowered to solve relevant problems. 3) Students are confident and have the skills to tackle future challenges" (p. 1). Finally, six key drivers of student success guided curriculum development. These included: "Research-backed instructional philosophy; relevant curriculum aligned with industry and postsecondary; teachers trained to be expert facilitators; engaging content; powerful student learning; and meaningful feedback and assessment" (p. 1). This theory of action guided the development of the App Creators computer science unit targeted at middle school students.

Powerful student learning. PLTW prioritized powerful student learning as part of the curriculum development process and defined it as the approach to teaching and learning that is scaffolded from structured to ill-structured experiences. The organization stated:

> Powerful Student Learning is the backbone of the PLTW experience. Problem solving is central to PLTW curricula; the Activities, Projects and Problem-based approach leads students to successfully tackle problems. A scaffolded approach leverages collaborative learning to allow students to build skills over time. Students are not "thrown into the deep end" of a problem, but are introduced to the problem, acquire the skills to address the problem, practice the skills, and then transfer the skills to wrestle with the problem and propose solutions. Problems are designed to maximize student choice and promote creativity. (Project Lead The Way, 2017f, p. 2)

Examples of powerful student learning by PLTW students was demonstrated in a series of case studies. In one example, students from Gulliver Preparatory School in Florida designed, developed, and delivered a water filtration system to provide clean water to individuals affected by the 2009 earthquake in Haiti (Project Lead The Way, 2017i). Encouraged by the success of the project, subsequent groups of students improved the design. According to PLTW teacher Claude Charron, "there have been 15 to 20 individuals involved with all aspects of the project, and there are now systems in five different countries. These updated, functioning systems are now in Haiti, Argentina, Nigeria, Kasai (The Congo), and The Philippines" (p. 3). Another case study highlighted the success of PLTW and Advanced Placement courses in a rural public school district in southeast Arkansas (Project Lead The Way, 2017e). Star City Superintendent Dr. Richard Montgomery stated, “there are numerous success stories ranging from special education students who for the first time in their school lives have had the opportunity to be truly included in challenging and meaningful curriculum to high-achieving students who previously could not see ‘beyond the books’” (p. 3). Additionally, Arkansas state test data supported the powerful combination of Advanced Placement and PLTW at Star City schools. Results from the 2015 state biology end-of-course exam showed:

> 73.5 percent of the students enrolled in PLTW Engineering, PLTW Biomedical Science, and/or PLTW Computer Science tested proficient/advanced on the end-of-course biology test compared with the combined population for Star City High School at 47 percent proficient/advanced and the state at 47 percent. This is the second consecutive year that Star City PLTW students have out-performed the state on the end-of-course biology by more than 20 percentage points. (p. 3)

An additional case study looked at the integration of Advanced Placement and PLTW at a public career and technical education center in Oklahoma City, Oklahoma (Project Lead The Way, 2017b). Outcomes of the pre-engineering academy at Francis Tuttle Technology Center included: “Ninety-eight percent of Academy graduates pursue higher education with more than 70 percent obtaining degrees in STEM. The 2014-15 graduating class of the Pre-Engineering Academy included five National Merit Scholars and two valedictorians” (p. 2). Additionally, the school reported positive student outcomes with the Biosciences and Medicine Academy including:

> Graduates of the Bioscience and Medicine Academy report their laboratory skills far exceed those of fellow students in college. Seven Academy graduates have

> recently been selected for programs that offer guaranteed admittance to medical school. The 2013-14 graduating class of 36 BSMA students earned $3.9 million in scholarships. For the 2013-14 graduating class of 36 seniors, all students continued on to higher education or military service upon graduation. (p. 4)

These case studies demonstrated student outcomes associated with PLTW coursework and the potential of curricula designed with powerful student learning in mind.

Research-backed instruction. According to Project Lead The Way (2017f), research and empirical evidence guided curricular development to ensure the most effective learning experiences for students. In the design and development of curricular content for students in kindergarten through twelfth grade, PLTW instructional designers relied on constructivist learning theory and other research-backed instructional strategies. According to the Project Lead The Way (2017f):

> Research-backed Instructional Strategies ensure the most respected, current, and relevant advancements in student learning are incorporated into PLTW student learning. While incorporating current research, PLTW also relies on Constructivist Learning Theories that create collaborative, highly engaging learning environments for students to build their own knowledge and understandings. (p. 1)

Constructivism as a learning theory has its roots in Dewey's approach to experiential learning. In his book, *Democracy and Education,* Dewey (1916) proposed, after close study of effective and permanent instructional methods across a variety of disciplines, efficient methods:

> go back to the type of the situation which causes reflection out of school in ordinary life. They give the pupils something to do, not something to learn; and the doing is of such a nature as to demand thinking, or the intentional noting of connections; learning naturally results. (Chapter 12, para. 4)

Constructivism built on Dewey's experimental learning or learning by doing. Proponents of constructivism (Perkins, 1991; Piaget, 1969; Vygotsky, 1978) theorized that individuals actively build, or construct, new knowledge through interacting with their environment. In this way, knowledge was not simply information delivered by an instructor and recalled by the student. Instead, knowledge was experienced and constructed in the mind of the learner. Glaserfeld (2001) expanded, "From the constructivist point of view, creating concepts is a form of construction and, whatever the circumstances, construction involves reflection, i.e. a recognition of the connections that can be made by coordinating sensory elements or mental operations" (p. 165). This method of constructing knowledge was in alignment with the activity-, project-, problem-based approach utilized by PLTW.

In addition to the underlying theoretical approach to instruction, the research-based framework used by PLTW in curricular design was Wiggins and McTighe's method entitled Understanding by Design (UbD). According to the organization, "Using backward mapping strategies, instructional designers start with the end in mind to identify goals, knowledge, and skills to address in each learning experience, thus creating a cohesive learning progression for the student" (Project Lead The Way, 2017f, p. 3). According to Wiggins and McTighe (2011), Understanding by Design (UbD) reflected "research on learning and cognition that highlights the centrality of teaching and assessing for understanding, and a helpful and time-honored process for curriculum writing" (p. 3). A key tenant of UbD was the backward planning of curriculum. Curriculum designers began with long-term desired outcomes and worked backward through a three-stage process including Desired Results, Evidence, and Learning Plan. The two big ideas of UbD were understanding and design. Wiggins and McTighe (2011) stated "UbD is predicated on the idea that long-term achievement gains are more likely when teachers teach for understanding of transferable concepts and processes while giving learners multiple opportunities to apply their learning in meaningful (i.e., authentic) contexts" (p. 4). Students construct meaning, or come to an understanding, through the process of transferring learning to new situations. The power in backward planning was clearly defining the desired learning outcomes and the evidence that will show learning has occurred before developing lessons. In conclusion, UbD challenges educators to start with what students should be able to do with content instead of starting with the content itself.

Project Lead The Way (2017j) described the organization's approach to student learning as activity-, project-, and problem-based instruction, abbreviated APB for Activity, Project, and proBlem:

> The activity-, project-, problem-based (APB) instructional model is a cornerstone of the PLTW learning experience. Using this approach, we scaffold knowledge – helping students build on their understanding and gain independence in the learning process, providing opportunities for students to transfer knowledge, and engaging students as they apply their new learnings to a relevant problem. (Project Lead The Way, 2017h, p. 3)

According to the organization, in this approach, “a problem is used to frame a unit of study and hands-on activities and projects provide a scaffold for developing knowledge and skills that are applied in solving an open-end, real-world problem” (p. 1). The APB approached was designed to create a continuum of learning for students as they progressed from well-defined learning experiences, entitled activities, to an ill-structured problem where students applied relevant knowledge and skills. PLTW proposed “as students engage in the learning experiences, they develop competencies and problem solving abilities” (p. 2). Krauss and Boss (2013) described this process as “actively gathering information, making observations, formulating questions, and then creating new ideas or solutions to answer their own inquiries. Critical thinking is embedded throughout the process” (p. 31).

Lambros (2002) described the problem-based learning approach as “a method based on the principle of using a problem as the starting point for the acquisition of new knowledge” (p. 1). Therefore, by creating a problem scenario that is real-world and relevant to the learner’s world, educators can “effectively eliminate[s] the students’ often posed question, ‘Why do we need to know this?’” (Lambros, year, p. viii). As students are engaged in this approach to learning, they learn to become conscious of the information they already know about the problem and identify the information they need to acquire to solve the problem. Additionally, students identify strategies they can apply to solve the problem (Center for Teaching and Learning, 2001). Hmelo-Silver (2004) concluded, “Problem-based learning is well suited to helping students become active learners because it situates learning in real-world problems and makes students responsible for their learning” (p. 236). Students “gain important knowledge, skills, and dispositions" as they work collaboratively to investigate open-ended questions (Krauss & Boss, 2013, p. 5). A successful problem-based approach is critically dependent on the instructor's scaffolding of students' active learning and knowledge construction (Amador, Miles, & Peters, 2006; Duch, Groh, & Allen, 2001). It is this problem-based approach that PLTW touted as the cornerstone of its approach to curricular design (Project Lead The Way, 2017f).

In PLTW's activity-, project-, problem-based approach, activities were the most structured experiences designed for students to acquire new knowledge and skills (2017c). The organization described the purpose of activities as experiences that "set the stage for developing the content skills and understandings that will help students successfully navigate the design problem. While activities may be directed, they are still designed for hands-on, engaged student learning" (slide 6). Projects were less structured and designed for meaning making. They "provide investigations into concepts or skills that will be applied in solving the design challenge" (slide 7). Finally, problems represented the most ill-structured learning opportunity. Ill-structured problems are relevant and real world problems that can be encountered in daily life (Shin, Jonassen & McGhee, 2003). According to Project Lead The Way (2017c), "Problems are open-ended, with no clear or best solution intended. Problems are designed to provide a common challenge that will typically result in unique solutions that require the transfer of new and past knowledge and skills" (slide 8).

Teachers trained to be expert facilitators. Lambros (2002) stated "Too often, and in many traditional teaching styles, the teacher is doing a disproportionate amount of the work. The learners are often passive, waiting for direction or waiting for the opportunity to respond to the teacher" (p. vii). To remedy this, Lambros (2002) advocated for the role of the teacher to change from being a "presenter of information to a facilitator of a problem-solving process" (p. 23). PLTW embraced the teacher as facilitator role and specified:

> Through professional development, teachers gain the ongoing pedagogical content knowledge and content knowledge necessary to be Expert Facilitators of Student Learning. Teachers are viewed not as lecturers imparting knowledge to students, but as facilitators of complex learning; instruction and professional development is designed as such. (Project Lead The Way, 2017f, p. 2)

Project Lead The Way (2016) advocated for a paradigm shift away from traditional teaching which relied heavily on students reading content and teachers presenting information through lectures and is seen as the "expert who imparts knowledge to the students" (p. 1). Instead, the organization supported a model of teacher as a facilitator where the focus shifted "to building on the knowledge base of students in ways that allow students to take ownership of learning" (p. 1). In this environment, the classroom becomes learner-centered rather than teacher-centered. Students become actively engaged in developing understandings that may be applied in diverse settings. However, the role of the teacher is still vital to the learning experience, "teachers guide students to outcomes, not primarily by lecture, but by establishing a classroom environment conducive to inquiry, creativity, and deeper learning" (p. 1). Hmelo-Silver (2004) described a facilitator as "an expert learner, able to model good strategies for learning and thinking, rather than an expert in the content itself" (p. 245). In this way, the facilitator provided opportunities for learning that may be either guided or self-directed.

Project Lead The Way (2016) promoted facilitation as a model of teaching that "requires thoughtful navigation of the tension between being the expert and guiding the learner to discover meaning through engagement" (p. 2). In the activity-, project-, problem-based approach promoted by PLTW, teachers had multiple roles in the classroom when acting as a facilitator of learning (2016). PLTW described the art of questioning as one of the key strategies teachers should develop to effectively facilitate problem-based learning. According to Hmelo-Silver (2004) facilitation is an important, yet subtle skill that "involves knowing when an appropriate question is called for, when the students are going off track, and when the PBL (problem-based learning) process is stalled" (p. 245).

Meaningful feedback and assessment. According to PLTW, an integral component of effective instruction is meaningful feedback and assessment. The organization stated:

> Meaningful Feedback and Assessment allow students to monitor their own learning and always know how they are performing relative to learning goals. Without assessment, one is merely teaching and is left to assume the relevant knowledge and skills were learned. Assessment removes the assumption and provides assurance to both the student and teacher that learning was achieved. (Project Lead The Way, 2017f, p.3)

Meaningful feedback and assessment were provided through a balanced assessment approach. Within the PLTW curriculum, the balanced assessment approach included pre-assessments, formative assessments, and summative assessments (Project Lead The Way, 2017f).

Relevant curriculum aligned to career and post-secondary education. A final component of PLTW curricular design was the requirement of relevant curriculum aligned to career and post-secondary education. To ensure the activities, projects, and problems experienced by students were aligned to relevant careers and skills sought by employers, the organization looked for external validation and guidance through professional advisory committees and sought validation by third-party evaluators (Project Lead The Way, 2017f). The focus on career learning influenced the organization's approach to alignment to standards:

> Although designers consult relevant academic standards when designing student learning, PLTW learning experiences are not currently designed to replace core academic learning and therefore, do not intend nor claim to cover all academic standards. Considering the vast diversity of PLTW students and schools, curriculum is designed to interest and be relevant to all students, regardless of gender, geographic location, or socioeconomic background. (Project Lead The Way, 2017f, p. 2)

In summary, the organization prioritized skills desired by industry and post-secondary institutions as well as relevant and interesting student experiences.

Middle School Computer Science

Available curriculum. A variety of non-profit and for-profit organizations provided computer science curricula for students in middle school during the 2016-2017 and 2017-2018 school years. These programs had a diverse set of goals, teacher professional development support, and approach. Twelve such curricula were cataloged and described by Computer Science Education Week (2017a) and included the following organizations: Bootstrap, CodeHS, Code.org, Code Monkey, Codesters, Globaloria, PLTW, Pythonroom, Scalable, Game Design, ScratchEd, Tynker, and UC Davis C-STEM. According to Computer Science Education Week (2017b), out of this list, PLTW is one of five nonprofit organizations offering computer science to middle school students and educators. A detailed description of the PLTW computer science pathway highlighted a cohesive experience for students from kindergarten through 12th grade as well as a renowned professional development offering for teachers that provided confidence and skill building for novice and advanced teachers. A second organization offering middle school computer science curricula is Bootstrap, a nonprofit curriculum that teaches algebra, physics, and data science for students in grades 6-12 (Bootstrap, 2017). Teacher professional development for Bootstrap includes three-day workshops for schools and districts. Another curriculum provider in the middle school computer science space was Code.org. This well-funded nonprofit offered Computer Science Discoveries for students in grades 6-10 (Code.org, 2017). This introductory computer science course was designed to empower students to "create authentic artifacts and engage with computer science as a medium for creativity, communication, problem solving and fun" (para. 1). Teacher professional development includes a five-day summer workshop with ongoing online support. In addition to PLTW, Bootstrap, and Code.org, the nonprofit Creative Computing organization provides a seven-unit introduction to the Scratch programming language and focused on creativity, empowerment, and computing (Brennan, Balch, & Chung, 2014). The final nonprofit listed by Computer Science Education Week (2017a) is the UC Davis C-STEM program. The C-STEM Middle School curriculum can be offered in a sequence or integrated into the existing school curriculum and offers two courses centered on math and one on robotics (UC Davis, 2017).

Pair programming. Pair programming is a programming strategy used in the industry that has gained increasing acceptance in the middle school computer science classroom (Denner, Werner, Campe & Ortiz, 2014). PLTW (2017d) advocated for the use of pair programming in their computer science courses for grades kindergarten through 12th. In the App Creators student version, pair programming was defined as: "Two people working together to create a computer program. One person called the driver writes the code and explains the logic, while the other person, called the navigator, reviews it and gives feedback" (Project Lead The Way, 2017d). Denner et al. (2014) studied the impact of pair programming for learning and found "compared to working alone pair programming was advantageous for computational thinking and for building programming knowledge, particularly among less experienced students" (p. 277). The researchers collected data from 320 middle school students either working alone or with a partner on a programming task. The participants were randomly assigned to either work in a pair or individually and students ranged in age from 10 to 14 years old. The researchers administered a pre- and posttest survey and a performance assessment that measured computational thinking. The data showed that students working in pairs performed significantly better on the performance assessment measuring computational thinking than the students who worked individually.

Computer science educators. According to Montoya (2017), the United States has fallen behind similar countries in recruiting and retaining high-achieving students in teacher education programs. Additionally, individuals interested in becoming computer science teachers have not had the necessary support or clarity in teacher preparation programs. Compounding this problem, many states lacked a clear definition of a computer science teacher certification. A risk to this confusion and lack of support is that individuals interested in pursuing a career in computer science education choose to move on to other computing fields where compensation is competitive. Montoya (2017) advocated for exposing pre-service teachers to computer science as part of the required certification coursework as a solution to the computer science teacher shortage. In conclusion, Montoya (2017) stated:

> K-12 schools, particularly public schools, can no longer ignore computer science as a core discipline in the twenty-first century. Even for students who are not pursuing computing or other STEM-related careers, learning computer science offers students opportunities to increase critical thinking and problem-solving skills, improve math and science performance outcomes, and become producers, instead of solely consumers of ever-changing technologies. (p. 61)

To provide this critical skill as an integrated part of K-12 education, Montoya (2017) proposed that "states must commit to recruiting, preparing, and retaining a diverse, culturally competent teaching workforce" (p. 52).

Student Engagement

What is Student Engagement?

In the literature, student engagement has been described as a multifaceted construct which included three types of engagement: behavioral engagement, emotional engagement, and cognitive engagement (Fredricks, Blumenfeld, & Paris, 2004). Fredricks et al. (2004) defined these facets of engagement in the following way:

> Behavioral engagement draws on the idea of participation; it includes involvement in academic and social or extracurricular activities and is considered crucial for achieving positive academic outcomes and preventing dropping out. Emotional engagement encompasses positive and negative reactions to teachers, classmates, academics, and school and is presumed to create ties to an institution and influence willingness to do the work. Finally, cognitive engagement draws on the idea of investment; it incorporates thoughtfulness and willingness to exert the effort necessary to comprehend complex ideas and master difficult skills. (p. 60)

These three types of engagement illustrated the different ways students may feel connected to their work and their school. Although behavioral, cognitive, and emotional engagement may be defined independently, Fredricks et al. (2004) argued the synthesis of the three categories provides a more complete characterization of student engagement than any one component is able in isolation.

Lewis, Huebner, Malone, and Valois (2011) described student engagement as "a student's degree of active involvement in school through his or her thoughts, feelings, and actions" (p.251). Lewis et al. (2011) conducted a study of 779 adolescent students. Fifty-three percent of the participants were female and 62% were Caucasian. The researchers hypothesized the variable of student engagement and life satisfaction of adolescent students in the study would show bidirectional relationships. To test this hypothesis the researchers administered a measure of global life satisfaction and measures of cognitive, emotional, and behavioral engagement at two points in time, five months apart to students at a Southeastern United States middle school. A statistically significant bidirectional relationship was found between life satisfaction and cognitive engagement. However, the researchers did not find a statistically significant relationship between either life satisfaction and emotional student engagement or life satisfaction and behavioral student engagement. The importance of this study was that it provided additional evidence of the role of life satisfaction in early adolescents' engagement in schooling during the critical transition period between elementary and high school. Furthermore, the study contributed to the research that supported the importance of student engagement and life satisfaction in educational outcomes.

Fredricks et al. (2004) described cognitive engagement as students' understanding of the importance of school, their investment and learning, and the desire for a challenge in coursework. Furthermore, Klem and Connell (2004) stated that irrespective of the definition, student engagement generally has positive associations with preferred social, academic, and emotional learning outcomes. Additional arguments for why student engagement matters were outlined by Finn and Zimmer (2012):

1) Engagement behaviors are easily understood by practitioners as being essential to learning. Further, the relationship between engagement behavior and academic performance is confirmed repeatedly by empirical research.
2) Engagement behaviors can be seen in parallel forms in early and later years. As a result, dropping out of school can be understood as an endpoint of a process of withdrawal that may have had its beginnings in the elementary or middle grades. Students at risk of school failure or dropping out can be identified earlier rather than later.

3) Remaining engaged—persistence—is itself an important outcome of schooling. Forms of persistence range from continuing to work on a difficult class problem to graduating from high school to entering and completing postsecondary studies.
4) Engagement behaviors are responsive to teachers' and schools' practices, allowing for the possibility of improving achievement and attainment for students experiencing difficulties along the way. (p. 99)

These reasons support educator interest and intervention in student engagement as a strategy to reduce the likelihood of poor student outcomes including dropping out and anti-social behaviors later in life. For example, Finn and Zimmer (2012) found across grade levels, students who exhibited academic engagement behaviors including paying attention, coming to class prepared, participating in academic extracurricular activities, and completing homework demonstrated higher academic achievement than peers who were less engaged. These highly engaged behaviors are "especially important for students who face obstacles due to status risk factors such as coming from a low-income home or having a first language other than English" (Finn & Zimmer, 2012, p. 107). Finn and Zimmer (2012) conducted a study designed to explore the relationship between dropping out of high school and students' engagement in fourth and eighth grade. The data included achievement scores recorded from kindergarten through eighth grade, several intervals of engagement measures, and success or failure in the completion of high school. The participants in the study included 2,728 students who participated in Tennessee's Project STAR, the Student/Teacher Achievement Ratio longitudinal class-size study funded by the Tennessee General Assembly and conducted by the State

Department of Education (Achilles et al., 2008). Academic achievement was measured by generating a composite score for students in reading and math and was derived from scores by each student in grades kindergarten through third and in grades six through eight. Social and academic engagements were measured through a teacher completed instrument entitled the Student Participation Questionnaire, or SPQ. For this study, fourth-grade teachers completed the full-length SPQ as well as eighth-grade reading and mathematics teachers who completed a shortened version of the SPQ. In eighth grade, students' identification with school was measured with the Identification with School Questionnaire. The researchers analyzed the data using a series of two-level multileveled logistic regression analyses using the HLM program with graduation/dropout as the dependent variable. The results of the study included a moderately positive correlation with academic and social engagement with reading and mathematics, with a stronger correlation for academic engagement (*r*'s from 0.44 to 0.54) than for social engagement (*r*'s from 0.33 to 0.36). Additionally, a moderately positive correlation was found for academic and social engagement and high school graduation. Finally, statistical significance was found between students' academic and social behaviors in eighth grade and the likelihood of graduating high school. Finn and Zimmer concluded, "academic and social engagement in fourth and eighth grade contributed to students' decisions to remain in school and graduate or to leave school early" (p. 122). Furthermore, academically and socially engaged students are more likely to have increased achievement as well as receive positive responses from educators for their behavior and academic progress. These positive responses had a positive reinforcing effect on student social and academic engagement. Reversely, students who did not exhibit academic or social engagement behaviors were more likely to receive negative responses from educators, leading to decreased engagement over time. Therefore, the connection between demonstrated student engagement behaviors and teacher responses were reciprocal. The researchers concluded student social and academic engagement in elementary and middle school is predictive of later academic achievement in high school.

Engaging the middle school student. Mahatmya, Lohman, Matjasko, and Fedman Farb (2012) stated: "childhood and adolescence is a time of rapid growth signified by key developmental tasks that capture overt biological and physiological changes, significant cognitive advancements, emotional maturation, as well as new social relationships" (p. 46). The authors further defined three dimensions of student engagement including behavioral, cognitive, and emotional engagement. The behavioral engagement dimension describes a student's participation in academic and extracurricular activities and can be defined in three ways. The first description of behavioral engagement includes the presence of positive behavior and absence of disruptive behavior such as truancy. The second description involves learning and academic tasks and behaviors such as persistence and effort. The third description of behavioral engagement is concerned with participation in school-sponsored activities such as extracurricular or athletics. The cognitive engagement dimension describes a student's investment including a willingness to "comprehend complex ideas and master difficult skills" (p. 47). Finally, the emotional engagement dimension describes positive and negative emotions to teachers, peers, academics, and school and "is presumed to create ties to an institution and willingness to do the work" (p. 47). During adolescence, children experience increased academic expectations and responsibility as well as greater than before exposure and experience with new environments. Furthermore, Mahatmya et al. (2012) emphasized the importance of perceived autonomy during early adolescence as it relates to the three dimensions of student engagement. Specifically, the authors presented adolescence as a time of rapid physical and cognitive development where individuals become more deliberate, focused, and have increased capacity for self-reflection. Therefore, the authors describe adolescence as a crucial time in development for educators, parents, and other stakeholders to actively support positive engagement efforts and opportunities.

Conclusions

According to PLTW, a leading provider of computer science curriculum, assessment, and professional development, when creating student learning experiences, PLTW curriculum designers and developers make three conditions a priority: (1) Students are engaged in their own learning; (2) Students are empowered to solve relevant problems; and (3) Students are confident and have the skills to tackle future challenges (Jarr, personal communication, February 3, 2017). The key condition of student engagement was defined by PLTW within the described construct of behavioral, emotional, and cognitive engagement. In addition to student engagement, curriculum development at PLTW was guided by six key drivers of student success. These drivers were called "PLTW Essentials" and included: Research-backed Instructional Philosophy, Relevant Curriculum Aligned with Industry and Postsecondary, Teachers Are Trained to Be Expert Facilitators, Engaging Content, Powerful Student Learning, and Meaningful Feedback and Assessment (Project Lead The Way, 2017f). Curriculum development at Project Lead The Way was driven by these PLTW Essentials (Jarr, personal communication, February 3, 2017). However, a comprehensive evaluation of the PLTW middle school computer science units had not been conducted using these PLTW Essentials. A portion of this study aimed to analyze teacher evaluations based on these PLTW Essentials to evaluate the quality of an original and revised middle school computer science unit of study focused on mobile application development. An additional component of the study looked at student engagement as evaluated by the students themselves to rate their behavioral, emotional, and cognitive engagement levels with the original and revised unit of study. In the literature, student engagement has been described as a multifaceted construct which included three types of engagement: behavioral engagement, emotional engagement, and cognitive engagement (Fredricks, Blumenfeld, & Paris, 2004). Additionally, Lewis et al. (2011) described student engagement as "a student's degree of active involvement in school through his or her thoughts, feelings, and actions" (p.251). In addition to educational goals and student engagement, workforce demands and opportunities for economy stimulation, cybersecurity, and career growth opportunities demonstrated a need for additional formal education in computer science. In conclusion, the aim of this study was to add to the literature regarding course quality of middle school computer science curriculum and its impacts on student engagement.

CHAPTER III

METHODOLOGY

Introduction

This study addressed the need for high-quality computer science education at the middle school level. The purpose of this research endeavor was to evaluate the effectiveness of a revised middle school computer science curriculum on teacher and student evaluations of the course, including teacher evaluations of course quality and student evaluations of the student experience. The study also considered the differences between student and teacher evaluations of the computer science unit of study. Stakeholders in education, government, and workforce development have called for an increase in computer science education for students in primary and secondary grades (Nager & Atkinson, 2016; Project Lead The Way, 2016; The White House, Office of the Press Secretary, 2016; Wilson, Sudol, Stephenson, & Stehilk, 2010). Although the field of computer science has enjoyed a resurgence of interest in recent years the focus of existing research included students primarily at the secondary and post-secondary levels (Fluck et al., 2016). High-quality computer science curricula for the middle school level was crucial to increasing student engagement in both STEM and computer science fields, as well as better preparing students to be effective problem solvers and computational thinkers (Grover, Pea, & Cooper, 2016).

The following research questions were addressed:

1. What effect did the revision of a middle school computer science unit of study have on teacher evaluations of course quality?
2. What effect did the revision of a middle school computer science unit of study have on student evaluations of student engagement?
3. What were the differences between student and teacher evaluations of a middle school computer science unit of study?

Research Design

The researcher applied a quasi-experimental cohort study aimed to examine the effects of a revised middle school computer science unit of study on student and teacher evaluations of the course. According to Montero and León (2007), the quasi-experimental study design is applied in "natural settings where it is not possible to make random assignment or to control the order in which the tasks are presented" (p. 852). Several variations of this type of study exist, including the posttest only cohort design. In this design, the researcher selects groups from the same institution but from different cohorts. A posttest only design is appropriate in "situations where measures can be taken only after the treatment has been applied" (p. 853). Additionally, in this type of study, the researcher may not be the one who made the intervention. This type of design was appropriate for the study as students and teachers utilizing the new and revised curricula could not be randomly assigned to treatment groups nor could the order in which the tasks were presented be controlled by the researcher.

A mixed-methods research design was chosen for this study. According to Gay and Mills (2016), mixed-methods research combines both quantitative and qualitative research into a single study in an attempt to explore the research question or questions more fully than either method could reveal alone. More specifically, this study was a convergent parallel mixed-methods design, in which both the quantitative and qualitative data were collected concurrently throughout the study and given the same weight and attention (Gay & Mills, 2016). The advantage of this study design is "the strengths of qualitative data (e.g., data about the context) offset the weaknesses of quantitative data (e.g., ecological validity), and the strengths of quantitative data (e.g., generalizability) offset the weaknesses of qualitative data (e.g., context dependence)" (p. 429). Additionally, the accuracy of a given study is enhanced by collecting and integrating qualitative and quantitative data on the same phenomena. This is known as triangulation, defined by Creswell (2012) as "the process of corroborating evidence from different individuals, types of data, or methods of data collection" (p. 259).

The researcher collected data through four methods. These were: (a) two in-person student focus group meetings, (b) two online teacher focus group meetings, (c) two online student end-of-unit surveys, and (d) two online teacher end-of-unit surveys. The data collection methods were applied to obtain both quantitative and qualitative information from the sample. Qualitative data was collected through both the focus groups and open-ended questions on the surveys. Focus group research was applied as a method of providing a deeper understanding of students' and teachers' perceptions of the quality of the original and revised computer science units of study. According to Creswell (2012), the advantages of focus group research include the ability to collect information within a limited amount of time and from individuals who may be hesitant to share information. The researcher chose this approach to maximize the limited window of time for in-person discussions with students as well as encouraging hesitant teachers and students to divulge more information than they may during an individual interview or open-ended response on a survey. In addition to hosting focus groups, survey research was applied in this study. Gay and Mills (2016) described survey research as a method designed to elicit individual's opinions on a problem or issue. In this study, teachers were surveyed on their evaluation of course quality and students were surveyed on their evaluation of student engagement. The surveys included both quantitative and qualitative items to provide data for the mixed-model design.

The focus groups and surveys were administered to two cohorts of students and teachers. One cohort facilitated or experienced the original version of the curriculum and the second cohort facilitated or experienced the new version of the curriculum. The quasi-experiment cohort study allowed the researcher to investigate the effectiveness of a revised middle school computer science curriculum on teacher and student evaluations of the course including teacher evaluations of course quality and student evaluations of the student experience. The study also considered the relationship between student and teacher evaluations of the computer science unit of study.

Participants

The participants of this study included two cohorts of middle school teachers and students either facilitating or experiencing a computer science curriculum provided by the Project Lead The Way organization. During the spring of 2017, the first cohort experienced a nine-week unit entitled Introduction to Computer Science I. The second cohort experienced the updated version of the nine-week unit entitled App Creators in the fall of 2017. The cohorts were comprised of teachers and students located throughout the United States.

As of May 2017, there were 3,703 schools across the United States offering PLTW's Gateway program targeted at students in grades 6-8. In May and June of 2017, the organization distributed an online survey to all active PLTW Gateway teachers through a targeted email. At this time, the network included 1,284 individuals trained in Introduction to Computer Science 1. Eleven middle school teachers provided feedback for the ICS 1 unit. The second cohort of middle school students and teachers experienced the new unit, App Creators, in the fall of 2017. As of April 2018, the PLTW Gateway program included 4,216 schools. Of the active Gateway teachers at these sites, 681 individuals were accredited through the organization to teach App Creators. A total of 26 teachers responded to an end-of-unit survey. Table 1 below includes additional demographic information regarding the teacher participants.

Table 1

Demographics of Teacher Participants

	Introduction to Computer Science 1		App Creators	
Variable	*n*	*%*	*n*	*%*
Grade Taught				
Grade 6	2	18.18	1	4.17
Grade 7	1	9.09	13	54.17
Grade 8	8	81.82	10	41.67
Past PLTW Class Facilitation				
Teaching the unit for the first time	4	36.36	16	100.00
Had taught the unit for 2-3 years	7	63.64	0	0.00
Had taught another PLTW unit in the past	10	90.91	11	68.75

School Setting				
Rural	3	27.27	2	12.50
Urban/City Area	5	45.45	8	50.00
Suburban	3	27.27	6	37.50
School Structure				
Traditional Public School	10	90.91	14	87.50
Innovation School	1	9.09	0	0.00
Public Partial Magnet	0	0.00	1	6.25

In addition to ICS 1 teachers, the first cohort included students experiencing the unit during the spring of 2017. The survey was administered by PLTW through an online format as an embedded link in the online curriculum during May and June 2017. The response to the survey included 527 ICS 1 students in grades 6, 7, or 8. The second cohort also included students experiencing the App Creators unit. The response to the survey included 105 App Creators students in grades 6, 7, or 8. Table 2 below includes additional demographic information regarding the student participants.

Table 2

Demographics of Student Participants

	Introduction to Computer Science 1		App Creators	
Variable	*n*	%	*n*	%
Grade				
Grade 6	65	12.33	7	6.67
Grade 7	113	21.44	6	5.71
Grade 8	349	66.22	92	87.62

Past PLTW Class Participation				
Had taken a PLTW class in the past	176	33.44	67	64.42
Had not taken a PLTW class in the past	299	56.74	26	25.00
Not sure	52	9.87	11	10.58
Current PLTW Class Participation				
Enrolled in another PLTW class	95	18.03	26	25.00
Not enrolled in another PLTW class	359	68.12	61	58.65
Not sure	73	13.85	17	16.35
Language				
Speak a language other than English at Home	215	40.76	20	19.61
Do not speak a language other than English at home	270	51.20	68	66.67
Prefer not to answer	42	8.03	14	13.73
Race				
African-American (Non-Hispanic)	55	11.16	15	15.46
Asian/Pacific Islander	37	7.51	3	3.09
Caucasian/White (Non-Hispanic)	90	18.26	38	39.18
Latino or Hispanic	181	36.71	13	13.40
Native American of Aleut	21	4.26	0	0.00
Other	47	9.53	9	9.28
Prefer not to answer	62	12.58	19	19.59
Gender				
Male	238	47.6	37	36.63
Female	204	40.8	51	50.50
Prefer not to answer	58	11.6	13	12.87

Data Collection

To collect data for this project, the researcher worked with curriculum provider Project Lead The Way (PLTW) to acquire historical data. The organization provided data from a survey administered to teachers and students within the PLTW network who experienced either the original or revised version of a middle school computer science unit of study. The survey instruments used were developed by PLTW and were designed to provide insight into the student and teacher experience. Although the organization used this same data to evaluate the middle school program, this study expanded the use of the data to compare an existing and revised version of a unit of study. Both surveys were administered through Survey Monkey and IP addresses were not recorded (Project Lead The Way, 2017; Jarr, 2018). Dr. Jarr, the Vice President of Research and Program Effectiveness at PLTW, reported the teacher surveys were "developed in light of the PLTW Theory of Action to understand quality of instruction, teacher support, assessment, and media" (Personal communication, March 1, 2018). The student surveys were created to better understand the effect of the PLTW experience on student engagement and was "designed to measure three dimensions of student engagement with an emphasis on cognitive engagement" (Project Lead The Way, 2017, slide 3). According to PLTW (2017), the survey was influenced by existing student engagement literature and surveys but was ultimately written by team members employed by PLTW.

The first research question was related to teacher evaluations of course quality. The survey instrument targeted the PLTW Essential Keys to Student Success as defined by the organization. The instrument assessed five factors related to course quality, including Powerful Student Learning, Research-Backed Instruction, Teachers Trained to be Expert Facilitators, Meaningful Feedback and Assessment, and Relevant Curriculum Aligned to Career and Post-Secondary Education. The survey for the first cohort was provided to teachers through a series of targeted emails sent by the organization to active teachers within the PLTW network, see Appendix A. The survey for the second cohort was embedded in the online teacher version of the curriculum that was accessible only to active teachers within the PLTW network, see Appendix B. The first cohort data were collected between May 8 and June 2, 2017. The second cohort data were collected between December 15, 2017 and April 5, 2018. The data were collected at these times to coincide with the end of the semester and quarter dates for traditional school calendars. The surveys were anonymous and all data were self-reported. The version of the survey administered to the first cohort included 25 questions and the version administered to the second cohort included 21 questions. Twenty of the questions were identical for both versions. For the quantitative portion of the survey, participants responded to a series of Likert-type survey questions and comparison questions. In the qualitative portion of the survey, teachers responded to questions related to changes they made to the content, changes they suggested PLTW make to the content, and any additional comments they chose to share with the organization. Finally, participants provided demographic data including experience with the curriculum, the organization, and school setting at the end of the survey.

In addition to the survey, the researcher collected data to address research question one through two focus groups consisting of four to eight teachers who had completed or were currently facilitating the middle school computer science courses. A focus group was held for individuals teaching the original version of the curriculum and a separate focus group took place for teachers using the revised curriculum and was facilitated by researchers at the University of Colorado, Denver. Both focus groups were held in January 2018 and the transcripts were provided to PLTW in March 2018. The researcher obtained the transcripts from the organization. The focus groups were held through an online forum and took place in the evening for an hour. This arrangement allowed for teachers from across the PLTW network to participate. The focus groups were structured around the following five questions and were adapted from Achieve (2015):

1. (Warm-up question) What kinds of activities are you involved in outside of school?
2. What experience was the most engaging for your students and why?
3. What experience was the least engaging for your students and why?
4. How is your PLTW Computer Science course different from other classes you teach now or have taught in the past?
5. What else would you like us to know?

The second research question targeted student evaluation of the unit related to student engagement. The survey instrument assessed three facets of student engagement including cognitive, behavioral, and emotional engagement. To address the second question, the researcher acquired historical data from the curriculum provider. The organization provided data from a survey administered to PLTW students across the country who experienced either the original or revised version of a middle school computer science unit of study. The first cohort data were collected between May 8 and June 2, 2017. The second cohort data were collected between December 15, 2017 and

April 5, 2018. For the first cohort, targeted emails to teachers requested they have their student complete the online survey. Teachers then shared the link to the survey with their students. For the second cohort, PLTW embedded the survey link into the online curriculum in the student edition. Only students currently enrolled in the PLTW middle school unit could access the link to the online survey. The data were collected at these times to coincide with the end of the semester and quarter dates for traditional school calendars. The surveys were anonymous and all data were self-reported. The versions of the survey administered to both cohorts included 56 questions and were identical for both data collection time periods, see Appendix C. For the quantitative portion of the survey, participants responded to a series of Likert-type survey questions and comparison questions. In the qualitative portion of the survey, students responded to questions related to changes they would make to the class, and any additional comments they chose to share with the organization. Finally, participants provided demographic data including experience with the organization and current grade level.

In addition to the survey, the researcher collected data to address the second research question through two focus groups consisting of six to eight students who had completed or were currently experiencing the middle school computer science courses. A focus group was held for individuals enrolled in the original version of the curriculum and a separate focus group took place for students using the revised curriculum. Both focus groups were held in October 2017 after IRB approval was acquired. The focus groups were held at the PLTW National Summit in Orlando, Florida. This arrangement allowed students from across the PLTW network to participate as several student groups traveled to the Summit. The focus groups were structured around the following five questions and were adapted from Achieve (2015):

1. (Warm-up question) What kinds of activities are you involved in outside of school?
2. What was the most engaging or interesting experience you have had so far in your Computer Science class and why?
3. What was the least engaging or interesting experience you have had so far in your Computer Science class and why?
4. How is your PLTW Computer Science course different from your other classes?
5. What else would you like us to know?

To address research question three, the researcher analyzed the student and teacher survey and focus group data for the two versions of the course to identify if differences existed between the teacher and student evaluations of the middle school computer science units of study.

Analytical Methods

The researcher collected quantitative and qualitative data obtained through the study using a variety of methods including survey responses and focus groups. These data were organized and summarized using descriptive statistics. According to Salkind (2017), descriptive statistics are used to "organize and describe the characteristics of a collection of data" (p. 9). Additionally, the researcher used inferential statistics to understand the differences between the groups and determine if the results could be inferred of the general population (Gay & Mills, 2016). An independent samples *t*-test was used to examine the difference between two cohorts of students and two cohorts of teachers. This was an appropriate statistical analysis of the available data as this test is used to look at the difference between the means of two groups that are independent from one another (Salkind, 2017). The researcher chose a factorial analysis of variance (ANOVA) to analyze the interaction of the different curricula on both cohorts of students and teachers. The use of the factorial ANOVA was appropriate for this use as the test is designed to analyze the total variation between and within groups (Gay & Mills, 2016). For both the independent *t*-tests and the factorial ANOVA, the researcher set an alpha level at $p < .05$ to not obtain the findings by chance and prevent type I error (Creswell, 2012). Qualitative data were analyzed by the researcher using coding. According to Gay and Mills, (2016) the process of using codes and labels to mark or reference qualitative text may be used as a way to indicate meaning and patterns within the data. This is also an effective way to reduce the qualitative data down to a manageable form and size for analysis.

To analyze the first research question, independent samples *t*-tests were used to compare the teacher survey data as reported by teachers facilitating the original and updated versions of the curricula. The data were disaggregated into five subgroups as recommended by PLTW. To meet the traditional criteria for convergent and discriminant validity of near or above 0.5 for all factors a number of questions had to be removed (Senkpeil, personal communication, June 28, 2018). The survey reliability data, as well as the questions removed from the analysis, are listed in Table 3 below.

Table 3
Teacher Survey Reliability Data

Questions	Estimate	*SE*	Standardized Estimate	Individual Item Reliability	Composite Reliability	Average Variance Extracted
Student Experience						

In this course, students demonstrate creativity.	1.00	--	0.64	0.41		
In this course, students overcome setbacks and failure as part of learning.	1.06	0.05	0.70	0.49		
In this course, students gain confidence in their knowledge, skills, and abilities.	1.04	0.05	0.76	0.58		
In this course, students are eager to learn more about course topics on their own.	1.25	0.06	0.72	0.52	0.85	0.50
In this course, students are likely to take ownership of their own learning.	1.30	0.05	0.77	0.59		
In this course, students this course is written at an appropriate developmental level.	1.17	0.06	0.64	0.41		
Meaningful Feedback and Assessment						
How adequate did you find opportunities for student self-evaluation and reflection.	1.00	--	0.61	0.37		
How adequate did you find interim assessments throughout the course.	1.35	0.05	0.71	0.50	0.88	0.55
How adequate did you find formative assessment strategies embedded in the curriculum.	1.60	0.06	0.89	0.79		

How adequate did you find formative assessment strategies embedded in the teacher resources.	1.69	0.07	0.93	0.86		
How adequate did you find materials for preparing students for the End-of-Course Assessment.	1.38	0.06	0.66	0.44		
How satisfied are you with the support provided by PLTW on teacher resource and reference materials.	1.05	0.05	0.60	0.36		
Teacher Efficacy and Facilitator Support						
I know the steps to teach this course effectively.	1.00	--	0.81	0.66		
I understand course concepts well enough to be effective in facilitating this course.	0.89	0.03	0.75	0.56		
I have the knowledge of assessment that I need to facilitate this class well.	0.99	0.04	0.65	0.42	0.82	0.51
I am confident in using the PLTW Activity-Project-Problem learning strategy.	0.88	0.04	0.64	0.41		
I have the knowledge I need to differentiate the material in this course to meet the needs of all students.	0.96	0.04	0.69	0.48		
Relevant Curriculum Aligned to Career and Post-Secondary Education						

The content of the course aligns to learning outcomes that my administration values.	1.00	--	0.70	0.49		
The content of the course is accurate.	0.83	0.05	0.69	0.48		
The content of the course is up to date and current.	1.03	0.05	0.67	0.45	0.79	0.49
The content of the course prepares students with in-demand, transportable skills for long-term success in life and career.	1.17	0.05	0.75	0.56		
Engaging Media						
The multimedia feels current and cutting-edge.	1.00	--	0.82	0.67		
The course contains multimedia that is engaging.	1.04	0.02	0.90	0.81		
Contains multimedia that is appropriate in length.	0.83	0.03	0.80	0.64	0.90	0.69
The multimedia delivery is appropriate for students' developmental level.	0.84	0.03	0.80	0.64		
Removed Questions (Factor):						
In this course, students use relevant industry tools and technology. (Student Experience) How satisfied are you with the support provided by PLTW on ability to collaborate with and learn from other PLTW teachers. (Meaningful Feedback and Assessment) How satisfied are you with the support provided by PLTW on the PLTW ongoing training. (Meaningful Feedback and Assessment) I wonder whether I have the necessary skills to teach this course. (Teacher Efficacy and Facilitator Support) I would like to gain more content knowledge as it relates to this course. (Teacher Efficacy and Facilitator Support)						

I regularly use a variety of questioning techniques as a facilitation strategy. (Teacher Efficacy and Facilitator Support)
The content of the course allows an appropriate amount of time for deep learning. (Relevant Curriculum Aligned to Career and Post-Secondary Education)
The content of the course is free of bias and stereotypes. (Relevant Curriculum Aligned to Career and Post-Secondary Education)

The first subgroup was student experience; when creating learning experiences PLTW prioritizes student engagement in their own learning, student empowerment to solve relevant problems, and student confidence (Project Lead The Way, 2018). This question set included items such as "In this course, students gain confidence in their knowledge, skills, and abilities" (Jarr, personal communication, March 1, 2018). The second subgroup was meaningful feedback and assessment, described by PLTW as an assessment approach allowing students and teachers to monitor learning and always know how they are performing relative to learning goals (Project Lead The Way, 2018). These items asked teachers to rate how adequate they found interim, formative, and summative assessment strategies. The third subgroup was teacher efficacy and facilitator support, defined as the ability of the teacher to effectively facilitate the unit of study and included items such as "I understand course concepts well enough to be effective in facilitating this unit" (Jarr, personal communication, March 1, 2018). The fourth subgroup was relevant curriculum aligned to career and post-secondary education. This question set included items such as "The content of the unit prepares students with in-demand, transportable skills for long-term success in life and career." Finally, the last subgroup was engaging media. This question set included items such as "The multimedia feels current and cutting-edge." Finally, qualitative analysis measures were used to evaluate the focus group data collected from teachers facilitating the original and revised versions of the curricula as well as to analyze the open-ended questions within the survey instrument.

To analyze the second research question, independent samples *t*-tests were used to compare the student survey data as reported by students participating in the original and revised versions of the unit of study. The data were disaggregated by subgroups as recommended by PLTW. The analysis included four subgroups and two individual response items. The first question set was cognitive engagement, described as "The PLTW experience relative to investment in learning and willingness to exert effort to comprehend complex ideas or difficult skills" and included items such as "This class has helped me become interested in my own learning" (PLTW, 2017m, slide 19). The second question set was related to career interest, described as, "The PLTW experience relative to current interests and future career interests" and included items such as, "I am interested in a career that would allow me to use what I learned in this class" (2017m, slide 19). The third question set was related to teamwork and communication, described as, "The PLTW experience relative to opportunities to work with a team and communicate complex ideas" and included items such as, "While working on a team in this class, I was able to work with a classmate even if I disagreed with his or her idea" (2017m, slide 19). The fourth question set was problem-solving, defined by PLTW as, "The PLTW Experience relative to problem-solving skills and opportunities" and included items such as, "This class has improved my ability to learn from my mistakes" (2017m, slide 19). In addition to the four question sets, two items were analyzed independently. These were five-point Likert scale items and were the following statements: "I would recommend this class to a friend," and "I wish more of my classes were like this one" (2017m, slide 19). See Appendix D for a complete listing of the disaggregated subgroups by survey question. Additionally, qualitative analysis measures were used to evaluate the focus group data collected from students participating in the original and revised versions of the unit as well as to analyze the open-ended questions within the survey instrument.

To analyze the third research question, a factorial ANOVA was used to determine if a difference existed between student and teacher evaluations of both the original and revised versions of the unit of study. Qualitative analysis measures were used to evaluate the focus group and open response data collected from students and teachers to analyze the relationship between how each group evaluated the original and revised versions of the unit.

CHAPTER IV

FINDINGS AND CONCLUSIONS

Introduction

The purpose of this mixed-methods quasi-experiment cohort study was to evaluate the effectiveness of a revised middle school computer science curriculum on teacher and student evaluations of the course, including teacher evaluations of course quality and student evaluations of the student experience. Additionally, the study considered the differences between student and teacher evaluations of the computer science unit of study. Research for this study was collected from two cohorts of middle school teachers and students throughout the United States during the 2016-2017 and 2017-2018 school years.

The study was guided by the following research questions:

1. What effect did the revision of a middle school computer science unit of study have on teacher evaluations of course quality?
2. What effect did the revision of a middle school computer science unit of study have on student evaluations of student engagement?
3. What were the differences between student and teacher evaluations of a middle school computer science unit of study?

To address the research questions, the researcher collaborated with the curriculum provider to acquire historical survey data and teacher focus group transcripts. Additionally, the researcher facilitated student focus groups as part of the study. To explore the first research question related to teacher evaluations of course quality, the researcher analyzed survey data for five factors related to course quality: Powerful Student Learning, Research-Backed Instruction, Teachers Trained to be Expert Facilitators, Meaningful Feedback and Assessment, and Relevant Curriculum Aligned to Career and Post-Secondary Education. The researcher collected and analyzed additional qualitative data through open response items in the survey and two focus group sessions for teachers facilitating the units. A student survey targeting student evaluation of the unit related to student engagement addressed the second research question. Qualitative analysis of open response items and focus group replies provided additional insight into student evaluation of the two versions of the computer science curriculum. To investigate the third research question, related to the differences between the teacher and student evaluations of the middle school computer science units of study, the researcher analyzed the student and teacher survey and focus group data for the two versions of the course.

Findings

Research Question 1: What effect did the revision of a middle school computer science unit of study have on teacher evaluations of course quality?

To address research question one, the researcher leveraged both quantitative data from an online survey as well as qualitative data from open response survey items and focus group data. Eleven middle school teachers provided feedback for the Introduction to Computer Science 1 (ICS 1) unit and 26 middle school teachers provided feedback for the App Creators unit through the online survey. Additionally, two focus groups were conducted including one with four ICS 1 teachers and one with eight App Creators teachers.

All participants in the study completed a survey to evaluate their perception of the computer science unit they facilitated. The teachers replied to Likert-type survey questions related to student experience, meaningful feedback and assessment, teacher efficacy and support, relevant curriculum aligned to career and post-secondary education, multimedia, and net promoter score. No significant difference was found for the ratings based on computer science unit facilitated. The results are reported in Table 4.

Table 4

Teacher Survey Responses

	ICS 1		App Creators		
Variable	*M*	*SD*	*M*	*SD*	*t*
Student Experience	3.939	0.735	3.935	0.664	0.018[a]
Meaningful Assessment and Feedback	2.167	0.679	2.881	1.112	-1.941[b]
Teacher Efficacy and Support	3.470	1.085	3.700	0.794	-0.678[c]
Relevant Curriculum Aligned to Career and Post-Secondary Education	3.485	0.821	3.904	0.836	-1.330[d]
Multimedia	3.432	0.874	3.987	0.729	-1.869[d]
Net Promoter Score	7.180	2.316	8.110	1.969	-1.161[d]

[a] *df* = 32
[b] *df* = 30
[c] *df* = 29
[d] *df* = 28

In addition to the subcategories, individual items were compared using independent samples *t*-tests. Of these questions, only one was found to be significant.

Question 31 asked teachers to respond to the Likert-scale question, "Thinking about the content of the unit, indicate how frequently each of the following occurs: The content of the unit prepares students with skills that employers seek." Teachers who facilitated the revised unit, App Creators ($M = 3.36$, $SD = .75$) more strongly agreed with the statement as compared to teachers who facilitated the original unit, Introduction to Computer Science 1 ($M = 4.06$, $SD = 1.06$), $t\ (28) = 2.08$, $p < .05$.

In addition to the quantitative data, the teacher survey included open response items. Using qualitative analysis methods, the teacher responses were coded and the researcher evaluated the data for emerging themes. The first open response item asked participants, "Why did you – or did you not – make changes to this unit?" The qualitative analysis of the ICS 1 teacher responses showed a pattern of response indicating the reading level of the unit was too high for students. Thirty-three percent of teacher participants reported concerns about the reading level as shown in the examples below:

> *ICS 1 Teacher #8:* "I needed to scaffold for my students. They had difficulty with the reading level of the APBs."
>
> *ICS 1 Teacher #10*: "Some students have problems following directions; many students have low reading levels."

Additional motivation for making changes to the unit included the ability level of students and the overall difficulty of the unit.

> *ICS 1 Teacher #9:* "To fit or schedule or ability levels of students."
>
> *ICS 1 Teacher #10*: "Concepts shown only once and not explained to the specific why you do something."

Upon qualitative analysis of the App Creators (AC) teacher responses, two main themes arose from the data, including meeting the needs of lower performing and advanced students as well as adding supplemental curricular materials. To begin with, 26.26% of the replies were by teachers who reported modifying the unit to meet the needs of lower performing or advanced students as represented by the following responses:

AC Teacher #14: "I made changes because it met the needs of my students. Most of the changes were to include the optional activities to require. A few times I had to adjust to lower expectation for challenged students."

AC Teacher #15: "I also had to start accompanying the instructions with screencast videos of me walking the students through the instructions for those low flyers. App creators is great for the advanced students but it needs more scaffolding for the average and below average students."

AC Teacher #16: "To extend the learning and take it deeper for advanced students or adjust for struggling learners."

AC Teacher #17: "I made changes to my unit to accommodate for my Special Ed students."

AC Teacher #18: "For student IEP and 504's"

AC Teacher #30: "I needed to adapt it to the time frame and the abilities of the students."

Additionally, 13.33% of App Creators teachers who provided feedback to the prompt mentioned adding material to supplement the curriculum as shown by the sample responses below:

AC Teacher #15: "I did not really change the units but I did add outside assignments that align with the curriculum to help entice the students and perk their interest."

AC Teacher #38: "At times I have added additional things to fill gaps within the curriculum that the students often like to use for their final projects."

AC Teacher #36: "I have created assessments. Something PLTW seems to forget is that most teachers are required to give letter grades. A rubric is great, yet, I find myself creating checkpoints, to make a grade."

Following the Net Promotor Score survey item, the second open response item asked teachers: "What changes would PLTW have to make for you to give it a higher rating?" The themes that emerged from qualitative analysis of the responses included suggestions related to age appropriateness of the unit and more resources for teacher support. Twenty-five percent of teachers responding to the prompt expressed concern about the age-appropriateness of the ICS 1 unit as shown in the examples below:

Teacher #9: "I believe the time allotted is not enough for a middle school setting."

Teacher #11: "Not at a middle school level. Needed to modify it a lot to meet needs of students."

Additionally, teachers requested more support through either the curriculum or other ICS 1 teachers:

Teacher #3: "I would also like more collaboration with other teachers since I know there are times I need an opinion or a quick explanation of something that it's going correct for me."

Teacher #7: "Answer keys could be written in a manner that would be understandable by novice (limited computer knowledge) teachers. Possible ideas or websites to improve computer science skills."

Similarly to the ICS 1 teacher responses, App Creators teachers' responses to the Net Promotor Score follow up question revealed themes of age-appropriateness of the content. Eighteen percent of the responses referred to the content as too challenging or not engaging for middle school students as demonstrated by the following examples:

AC Teacher #25: "I feel that this App Creators course is very difficult for middle school and the directions for the lessons are not clear. I hope that this gets better, but my last class was really not into the material. I think it's a good concept, but the lessons need to be geared more to middle school students and not as hard."

AC Teacher #7: "Have the curriculum relate to a middle school student that will keep their interest. Right now, it is boring and dry for middle school students."

Additionally, 18.18% of App Creators teachers commented on the use of health and biomedical science as a part of the unit. Analysis of these responses indicated a desire for more game creation and less focus on medical content:

AC Teacher #19: "The projects at the end of Lesson 1 and Lesson 2 both were part of the health/medical field (and some of the activities were as well). Even one of the options they gave the students to consider for the Problem in Lesson 3 fit in that category. Students that were disinterested in the health/medical field tended to be disinterested many of the activities and projects."

AC Teacher #29: "Students enjoy building games. Having more lessons tiered towards games would add even more interest."

Finally, both ICS 1 and App Creators teachers were prompted to: "Please include any additional comments you would like to share regarding your PLTW experience." Upon qualitative analysis of the short-answer responses, no themes emerged from either the ICS 1 or App Creators teachers. However, one ICS 1 teacher provided the following positive response:

> *Teacher #7:* "I absolutely love the PLTW methods/curriculum. I could not have taught nor felt empowered to teach these topics without this program."

In January 2018, two teacher focus groups were conducted, one for teachers facilitating the ICS 1 course and one for the App Creators course. The teachers provided feedback on their general impressions of the unit, student engagement, how the unit was different from other CS courses, and the training experience. Teachers also offered additional comments and suggestions.

The ICS 1 teachers reported they enjoyed teaching the course; however, most of the participants preferred the App Creators course to ICS 1. Teachers expressed frustration with the software, specifically Python and Canopy, and communicated concerns the content was too much for students to handle. Teachers also reported most of their colleagues were teaching ICS 1 differently than how they were trained to teach the course, which was not their experience with other classes, such as Design and Modeling. For example, one participant stated, "ICS was a tool in my toolbox and I just used it as that, it is more of a reference than a curriculum." Overall, the ICS 1 participants felt the unit did not meet their expectations, especially the Python content.

The ICS 1 teachers felt the least engaging aspect of the unit was Python. Although they did concede students were learning valuable skills, they expressed concerns the experience was not fun, even when students were creating games. When asked how to make Python engaging, one participant stated,

> *ICS Interviewee:* It's really hard to make it – I did it where I was breaking the course into chunks and we were doing it with other activities – not following the ICS course line. If we did Python all at once, it was kind of a drain. I would say Python was the least engaging component of the course.

During the focus group, the moderator asked teachers to share how the ICS 1 course was different from other courses they teach. Several of the teachers described how they modified the course or developed their own curriculum to resemble other courses they teach. One participant explained, "It's different from the other PLTW course that I teach. This is very much my own course." In addition to creating their own content to supplement the unit, teachers in the focus group reported utilizing content from other sources specifically for the Python content. Similarly, another interviewee described how different the experience was with ICS as compared to other PLTW middle school units.

> *ICS Interviewee:* With ICS, I feel like everybody that I talk to that's teaching ICS is teaching it differently than they were trained. That is not my experience with other classes. Like other classes, even in our building, that we're teaching, or Design and Modeling, I mean, I teach Project Lead The Way Design and Modeling, and I like Project Lead The Way Design and Modeling. Obviously, there are some things I've changed just for teaching style, but it's not like ICS where I changed so much.

Finally, a teacher suggested PLTW redesign the ICS course to be more of a survey course to generate interest and excitement:

ICS 1 Interviewee: "Do a couple of weeks on virtual reality. Do a couple of weeks on Python. Do a couple of weeks on Java and see how they relate to each other. Do a couple of weeks on App Creators and whatever else is out there. Be flexible and touch on different subjects."

In addition to the student experience, the focus group moderator asked teachers to reflect on the core training experience for ICS. A common theme among the focus group participants was the ICS training was challenging and the Master Teachers were generally not the same caliber as trainers for other PLTW courses as stated below:

*ICS 1 Interviewee: "*I don't feel like the master trainers were the master trainers I've experienced in other Project Lead The Way classes. To become a master trainer in Project Lead The Way is very in depth, to include like videotapes of yourself, and interviews. It's pretty difficult to become a trainer, and you have to be very faithful to the curriculum and teach it the way they present it. Our instructors, quite honestly, said, 'It's new; we don't really know what we're doing.'"

A separate focus group was held for teachers facilitating the App Creators course. The teachers provided feedback on their general impressions of the unit, student engagement, how the unit different from other CS courses, and the training experience. Teachers also offered additional comments and suggestions.

Teachers participating in the focus group reported positive impressions of the App Creators course: "App Inventor is very engaging. It's fun. They put it right on a tablet. It does stuff. It's very much immediate gratification." While they offered some ideas for improvement, participants were satisfied with the curriculum, the embedded activities and projects, and their students' engagement in the course. "Well, I'm going to say I am a huge fan. I absolutely love it. We had an incredible amount of success with the class." Teachers also reported the curriculum required students to think through computer science principles and they enjoyed the "open-endedness" of the curriculum. They also discussed the images and gifs that helped guide students through the activities while they learned how to use the App Inventor programming environment. Several teachers commented on the scaffolding of the curriculum and said it was well-thought-out. Additionally, one teacher commented on how the course differed from initial impressions,

> *AC Interviewee: "*When I first saw the curriculum and how difficult it was and trying to reverse engineer some of these programs, I thought they would revolt on me. I was pleasantly surprised with how they accomplished it."

Teachers in the focus group also commented on the connection to the community in the App Creators course and were enthusiastic about how the course included opportunities for students to solve real-life community problems.

> *AC Interviewee:* "This to me is really what education is about. It is a little bit deeper than just the computer science end. Just really the connections to the community, which is where we need to be in this 21st Century learning."

Teachers reported students chose to create apps that provided a community service instead of picking gaming projects.

Teachers reported high student engagement with the App Creators curriculum and expressed students benefited from this course.

> *AC Interviewee:* "It is really an empowering component when folks are doing the things that everyone thinks is cool."
>
> *AC Interviewee:* "I like the fact that we're teaching concepts that are universal to every language so the kids can learn some of those concepts, like the if/then statements, without getting bogged down in the technicalities of specific language and syntax."
>
> *AC Interviewee:* "I know that in my school, with the elective class, going into next year, the numbers have already doubled. That's definitely a testament to the program and the curriculum."
>
> *AC Interviewee:* "I straight up had a kid who told me he came to class because he felt like I was teaching him something that was worthwhile."

When asked about the most engaging experiences for students, teachers in the focus group reported high engagement in the game creation portion of the curriculum.

> *AC Interviewee:* "I've never heard students applaud themselves before, except when we were doing game time. It blew my mind. When kids were successful getting their little game to work, they were actually clapping their hands."

One teacher referred specifically to activity 1.7, which is the game time app. He said,

> That right there is a spark for them, and it really fuels them when they start thinking about what they want to create and using the canvas feature and so on to create games because their interests are right there.

In contrast to the highly engaging gaming aspect of the curriculum, teachers reported the least engaging experiences for students included reverse engineering apps and the Build-A-Body problem.

AC Interviewee: "When they start getting in and having to design the user interface and design it entirely themselves, they absolutely hit a wall because all of the skeleton apps, it's all done basically for them. There are a few things they have to do, but the vast majority of it is already laid out."

AC Interviewee: "The biomedical theme is something I understand Project Lead the Way is trying to do in putting the theme across all of the different strands, but it's a force fit at best."

Specifically, several of the focus group participants reported students were excited about the Game Time app and then lost interest when they started with the Build-A-Body app.

Teachers reported the App Creators curriculum was different from other computer science courses in that it was very student-driven and project-based. Two teachers noted there were opportunities for lower-functioning students to experience success:

AC Interviewee: "Every lesson has a low entry and a high exit. These kids that really struggle in other classes end up having the same kinds of positive experience that the higher functioning kids have, and I really like that."

AC Interviewee: "I've had several students with autism absolutely thrive in this curriculum, which is amazing because their brains are wired to see this logically. That has been amazing to be able to meet their needs in this way."

Project Lead The Way teachers may attend core training in the summer or online during the school year. Teachers in the focus group participated in summer core training and reported the instructors were effective. However, many of the teachers expressed the App Creators training needed significantly fewer assignments.

AC Interviewee: "We have 16 submission assignments compared to CSIM having five, Automation Robotics having seven. I don't know about the other ones, but just the sheer volume of submission assignments is incredible, it's too much."

To remedy this, one teacher suggested many of the assignments could be combined or streamlined. Finally, teachers expressed they wished they had known to attend core training for Computer Science for Innovators and Makers (CSIM) first and App Creators second. For example, one teacher stated, "I thought the CSIM was a lot easier. I would say that the CSIM is what you should take first before App Creators."

Although teachers gave overwhelmingly positive feedback about the App Creators curriculum, the focus group participants had suggestions for improvement. For example, one teacher expressed some students struggled with the projects, "It's a little bit of a jumping off the cliff when it gets to the projects." Another interviewee expressed frustration to the way the curriculum introduced binary code, "Oh, let's learn about binary code for a quick second, and then we're going to move on to something else." Furthermore, another interviewee felt the curriculum spent too much time and went too in depth with images and gifs and she simplified this portion of the content. In addition to content suggestions, teachers expressed concern that the timing of the curriculum was difficult and felt they had to rush their students through the activities, projects, and problems.

Research Question 2: What effect did the revision of a middle school computer science unit of study have on student evaluations of student engagement?

PLTW administered an online survey available to all students enrolled in PLTW's Introduction to Computer Science 1 (ICS 1) unit in the spring of 2017 and App Creators unit in winter 2018. The responses included 527 ICS 1 students and 105 App Creators students. The student survey data was disaggregated by subgroups as recommended by PLTW.

The first question set was cognitive engagement with the PLTW curriculum as reported by students experiencing an original and revised version of a 9-week computer science unit. PLTW defined cognitive engagement as, “The PLTW experience relative to investment in learning and willingness to exert effort to comprehend complex ideas or difficult skills” (PLTW, 2017, slide 19) and included items such as, “This class has helped me become interested in my own learning” (slide 19). An independent samples *t*-test was run to analyze the difference in cognitive engagement between students experiencing the original and revised computer science curricula. A significant difference was found between the two groups, these results are reported in Table 5.

The second question set was career interest. PLTW defined career interest as, “The PLTW experience relative to current interests and future career interests” (PLTW, 2017m, slide 19) and included items such as, “I am interested in a career that would allow me to use what I learned in this class” (slide 19). An independent samples *t*-test was run to analyze the difference in career interest between students experiencing the original and revised computer science curricula. A significant difference was found between the two groups, these results are reported in Table 5.

The third question set was focused on teamwork and communication. PLTW defined teamwork and communication as, “The PLTW experience relative to opportunities to work with a team and communicate complex ideas” (PLTW, 2017, slide 19) and included items such as, “While working on a team in this class, I was able to work with a classmate even if I disagreed with his or her idea" (slide 19). An independent samples *t*-test was run to analyze the difference in teamwork and communication between students experiencing the original and revised computer science curricula. A significant difference was found between the two groups, these results are reported in Table 5.

The fourth question set was focused on problem-solving. PLTW defined problem-solving as, "The PLTW Experience relative to problem-solving skills and opportunities" (PLTW, 2017m, slide 19) and included items such as, "This class has improved my ability to learn from my mistakes" (slide 19). An independent samples *t*-test was run to analyze the difference in problem-solving between students experiencing the original and revised computer science curricula. A significant difference was found between the two groups; these results are reported in Table 5.

Table 5

Student Survey Responses

	ICS 1		App Creators		
Variable	*M*	*SD*	*M*	*SD*	t^a
Cognitive Engagement	3.298	0.976	2.795	0.851	4.922**
Career Interest	3.239	0.998	2.779	0.844	4.409**
Teamwork and Communication Skills	3.419	0.932	3.205	0.808	2.190*
Problem Solving	3.407	1.052	2.984	0.982	3.798**

*$p < .05$. **$p < .001$.

$^a df = 630$

In addition to the question sets, two individual questions were analyzed to look for differences between the students' responses. An independent samples *t*-test was run to compare students' responses to the statement, "I would recommend this class to a friend." There was a significant difference between the original ICS 1 unit ($M = 3.34$, $SD = 1.28$), and the revised App Creators unit ($M = 2.44$, $SD = 1.22$), $t\ (630) = 6.66$, $p < .001$.

Additionally, the researcher ran an independent samples *t*-test to compare students' responses to the statement, "I wish more of my classes were like this one." There was a significant difference between the original ICS 1 unit ($M = 3.13$, $SD = 1.27$), and the revised App Creators unit ($M = 2.37$, $SD = 1.24$), $t\ (630) = 5.61$, $p < .001$.

Students from both cohorts were asked to respond to two short answer items within each online survey. The first open-response item asked students: "If you could change anything about this class, what would you change?"

Using qualitative analysis methods, the responses were coded and the researcher evaluated the data for emerging themes. The themes that emerged from the Introduction to Computer Science 1 students included making the class more fun and changing or adding activities.

Of the 468 responses to this prompt, 4.67% of responses included data requesting the class present information in a more fun and interesting manner:

> *ICS 1 Student #147:* "If I could change anything in this class I would change the way the information is presented to us, maybe in a more fun and interactive way."
>
> *ICS 1 Student #502: "*If I could change anything about this class, it would be making the learning more fun, in an attempt to fully grasp my attention."

Furthermore, 3.85% of ICS 1 responses included references to changing or adding activities.

ICS 1 Student #139: "I would try more coding activities that are different from each other."

ICS 1 Student #269: "The fact that there isn't enough activities to do way more coding beyond us."

Resembling ICS 1 students, App Creators student data showed themes of making the content more interesting and fun. For example, 8.52% of the responses from App Creators students included feedback regarding making the class more fun or interesting.

AC Student #110: "If I could change anything about this class I would change the way it is taught, and make it way more interesting."

AC Student #138: "I would change how boring it is they should make it fun."

Unlike ICS 1 students, 20.21% of App Creators students commented on making changes to the teacher or behavior of the teacher.

AC Student #188: "I would honestly change the teacher."

AC Student #190: "To be honest the teacher. She is a semi-nice person but what stood out was that she didn't help when you needed it."

Within the student responses regarding the teacher, a theme of student autonomy emerged. Representative quotes are below:

AC Student #175: "If I could change anything about this class it'd be the fact that the teacher wouldn't take over the screen and actually let us do our work."

AC Student #191: "The teacher being able to control all the computers; stop WEB SHARING."

In addition to the activities and teacher, three of the 94 responses included requests to make the content easier.

AC Student #123: "I would change things to be easier to get."

AC Student #147: "I would make the apps easier to create and I wouldn't have to name everything perfectly."

AC Student #161: "I would make it more one-on-one learning and easier directions."

The second open-response item asked students: "What else would you like us to know?" The themes of fun and the future or jobs emerged for both the ICS 1 and App Creators students. Within the ICS 1 student survey, 8.02% of responses alluded to the experience being fun as well as 6.58% of App Creators students. Examples of these comments include:

ICS 1 Student #370: "This class is one of my favorites because we get to do lots of fun activities and projects as a team."

ICS 1 Student #387: "That this class is very fun and it encourages me to do more things on coding, programming, and creating things on devices."

AC Student #111: "This class was very fun and I thought it was easy. :)"

AC Student #114: "The partner work was pretty fun."

Furthermore, the theme of the future or jobs appeared for both cohorts. Fifteen of the 424 ICS 1 student responses included a reference to how this course would help the student in the future.

ICS 1 Student #260: "This class definitely taught me skills that I might need to know one day for a future job."

ICS 1 Student #432: "I deeply enjoyed this class and the curriculum taught and think it will help me greatly in the future."

Similarly, 3.95% of App Creators students included comments about how the course would prepare them for a job or career.

AC Student #123: "This class is boring and kinda something that will help me in a job."

AC Student #134: "I really liked these lessons. And to be honest, I love coding, considering I want a job that involves what this class teaches in the future."

In addition to fun and the future, 5.66% of student responses for the ICS 1 unit referenced the teacher. The vast majority of students who commented on their teacher provided positive feedback as in the comments below:

ICS 1 Student #340: "I believe that a teacher can affect how much a student enjoys a class, and I strongly believe my teacher made me love this class."

ICS 1 Student #516: "I would like you to know that the teacher was amazing and never gave up on us."

Finally, the theme of a boring class emerged as a theme from App Creators students with 5.26% of responses referencing the term "boring" as in the example below:

AC Student #188: "The class was very boring."

In October 2017, two student focus groups were conducted, one for students experiencing the ICS 1 course and one for the App Creators course. The students provided feedback on their general impressions of the unit, student engagement, how the unit differed from other computer science courses, and suggestions for improvement.

Overall, students participating in the ICS 1 unit enjoyed the experience and reported learning new skills related to computer science through the course. Students enjoyed creating their own tablet applications. One student stated, “I liked when we got to create our own app and program it by ourselves.” As for student engagement, ICS 1 students reported the highest levels of engagement when they created tablet applications from scratch and when their applications were successful. Conversely, students reported the least engaging or interesting part of the course was learning the specifics of the MIT App Inventor programming environment. When asked what the least engaging part of the class was students responded with the following:

> *ICS 1 Interviewee:* “When we first started to learn what each block was. This is here and there. I like just exploring like where everything is kept. The drawer where everything is kept to learn was not that engaging.”
>
> *ICS 1 Interviewee:* “Nothing really bothered me that much. I just got bored when we had to sit on the computer and fix our design and stuff. Like just sit there forever. So maybe if it was more interactive?”

Students also reported frustration and disengagement when they could not get their code to function as intended.

> *ICS 1 Interviewee:* “I didn’t like when I messed up on my code and I had to go back and do it all over again.”

In addition to student engagement, the focus group participants reflected on how their PLTW ICS 1 class was different from other courses they had taken in school. Although a few students noted it was similar to their other courses, several students thought the experience was different in that the PLTW course required more critical-thinking, iteration and problem-solving.

*ICS 1 Interviewee: "*I personally think it's not that different from our other classes. It's usually just trial and error and how we learn from our mistakes in my classes are similar."

*ICS 1 Interviewee: "*I think it's different because like when you are in computer science you really have to think through stuff. Like if I do this the result of that will be this and like it matters if I like to three multiples of six or something."

ICS 1 Interviewee: "I just think it's like you get more critical thinking time in PLTW. In other classes you just get your notes, classwork, and homework."

ICS 1 Interviewee: "I also think the design process helped me think through like a lot of different problems. So like before I was in PLTW courses I would be like how am I going to solve this problem. But after I was in PLTW it made me think through the problem and not have so much worry because you just need to think through it. PLTW helped me think better I guess."

Students experiencing the ICS 1 course provided suggestions for improvement, including less group work and paired programming. When asked about working in pairs or groups the students responded as follows:

ICS 1 Interviewee: "I try to work independently because I'm an independent person and I will ask another student if they know what they are doing but I like to work independently."

*ICS 1 Interviewee: "*I agree with her, I'm a more independent person and I just like to ask around if I don't understand something or figure it out myself."

App Creators students participated in a separate focus group. The students provided feedback on their general impressions of the unit, student engagement, how the unit differed from other courses, and suggestions for improvement.

In general, students participating in the App Creators course enjoyed the unit and found the experience of creating mobile applications a valuable use of their time. However, they did express frustration with the limits of the types of mobile applications they could create, as well as the inability to start an application design from scratch. One student reported high engagement with the course by expressing excitement about "making an app that actually works for the first time, without any guidelines." Several other students reported engagement with creating functioning apps as reported below when asked what the most engaging part of the course was:

> *AC Interviewee:* "Learn the basics of how to make an app (inaudible)…to maybe make an app in the future."
>
> *AC Interviewee:* "Just the experience of making the app and getting to create, getting to enjoy the experience, make what you like, made me think other people would like it too."
>
> *AC Interviewee:* "The thing I like most is like when we had 'it's my turn' app and we can do anything we want and we have like free stuff so we can do everything pretty much."

Students also responded to how the unit differed from their other courses. Students reported their App Creators course allowed them to learn more and create what they want. One student complained, *AC Interviewee:* Other classes they tell you what to do. What to study, tell you how to do things, but in the class you're able to do things the way you want to learn, start how you want and to start, just create and advance on your own.

Similarly, another student stated,

AC Interviewee: Usually in other classes it's like 'Get your Chromebook and start doing this, like please type in this, start studying this.' Like PLTW it's 'Get your Chromebook and start coding.' It's like, in other classes they tell you what to do but in Computer Science they let you do whatever you can do.

Finally, when asked about what they would change to improve the course, App Creators students suggested specific improvements to the MIT App Inventor programming environment but did not comment on the content of the curriculum. However, students did express frustration with the experience of coding but explained this was both a good and bad type of frustration as represented by the following statement:

AC Interviewee: It's both like you always have pressure to like things you do and even though you're using your creativity, you still get frustrated, but you always go back. Like, it will, you'll be frustrated but the next day you can go back and start fresh and start thinking of different ways to do it. But then, sometimes it's bad because you feel like you're defeated and you feel like, "Oh, I can't do it." You can figure it out.

Research Question 3: What were the differences between student and teacher evaluations of a middle school computer science unit of study?

The differences between student and teacher evaluations of the two computer science units were determined through an analysis of student and teacher quantitative and qualitative survey responses as well as focus group data. To analyze the third research question, the researcher used a factorial ANOVA to determine if a difference existed between student and teacher evaluations of both the original and revised versions of the unit of study. The analysis included four subgroups including student confidence, student career readiness, ownership of learning, and recommendation of the unit.

To analyze the differences between student and teacher perceptions of the unit of study on student confidence, the researcher compared similar student and teacher survey questions. The student question was a Likert-scale question in which students responded to the statement: "This class helped me gain confidence to overcome challenges." The teacher question was a Likert-scale question in which teachers responded to the statement: "In this course, students gain confidence in their knowledge, skills, and abilities." Confidence levels were compared by unit and group using a factorial ANOVA which showed a significant difference between students and teachers, F (1, 662) = 25.19, $p < .001$. There was not a significant difference among the units, F (1, 662) = 1.31, and the interaction between unit and group was not significant, F (1, 662) = 1.27. The descriptive statistics for these comparisons are shown in Table 6.

Table 6
Descriptive Statistics of Confidence by Unit and Group

	Students		Teachers		Students and Teachers by Unit	
Unit	*M*	*SD*	*M*	*SD*	*M*	*SD*
ICS 1	3.20	1.22	4.09	0.70	3.22	1.22
App Creators	2.68	1.20	4.09	0.85	2.93	1.27
ICS 1 and App Creators	3.11	1.23	4.09	0.79		

To analyze the differences between student and teacher perceptions of the unit of study on student career readiness, the researcher compared similar student and teacher survey questions. The student question was a Likert-scale question in which students responded to the statement: "I think what I have learned in this class will help me in a job someday." The teacher question was a Likert-scale question in which teachers responded to the statement: "The content of the unit prepares students with skills that employers seek." Career readiness levels were compared by unit and group using a factorial ANOVA, which showed a significant difference in the interaction between the unit and group F (1, 658) = 5.75, $p < .01$. There was not a significant difference among the units, F (1, 658) = 0.49, nor among groups, F (1, 658) = 1.38. The descriptive statistics for these comparisons are shown in Table 7.

Table 7

Descriptive Statistics of Career Readiness by Unit and Group

	Students		Teachers		Students and Teachers by Unit	
Unit	*M*	*SD*	*M*	*SD*	*M*	*SD*
ICS 1	3.56	1.21	3.27	0.65	3.55	1.20
App Creators	3.16	1.15	4.00	1.05	3.29	1.67
ICS 1 and App Creators by Group	3.49	1.21	3.73	0.98		

To analyze the differences between student and teacher perceptions of the unit of study on ownership of learning, the researcher compared similar student and teacher survey questions. The student question was a Likert-scale question in which students responded to the statement: "This class has helped me become more interested in my own learning." The teacher question was a Likert-scale question in which teachers responded to the statement: "In this course, students are likely to take ownership of their own learning." Perceptions of ownership of learning were compared by unit and group using a factorial ANOVA, which showed a significant difference between students and teachers, F (1, 662) = 7.02, $p < .01$. There was not a significant difference between units, F (1, 662) = 2.30, and the interaction between unit and group was not significant, F (1, 662) = 0.35. The descriptive statistics for these comparisons are shown in Table 8.

Table 8

Descriptive Statistics of Ownership of Learning by Unit and Group

	Students		Teachers		Students and Teachers by Unit	
Unit	*M*	*SD*	*M*	*SD*	*M*	*SD*
ICS 1	3.27	1.18	3.73	0.79	3.28	1.17
App Creators	2.80	1.17	3.52	0.95	2.93	1.17
ICS 1 and App Creators	3.19	1.19	3.59	0.89		

To analyze the differences between student and teacher recommendations of the unit of study, the researcher compared similar student and teacher survey questions. The student question was a Likert-scale question in which students responded to the statement: "I would recommend this class to a friend." The teacher question was structured as a Net Promoter Score in which teachers responded to the statement with a rating of 1-10: "How likely is it that you would recommend this unit to a friend or colleague?" To compare these items, the results were transformed into a standardized scale prior to running the analysis. Course recommendations were compared by unit and group using a factorial ANOVA, which showed a significant difference in the interaction between the unit and group *F* (1, 658) = 8.72, $p < .01$. There was not a significant difference among the units, *F* (1, 658) = 0.44, nor among groups, *F* (1, 658) = 0.81. The descriptive statistics for these comparisons are shown in Table 9.

Table 9

Descriptive Statistics of Course Recommendation by Unit and Group

	Students		Teachers		Students and Teachers by Unit	
Unit	*M*	*SD*	*M*	*SD*	*M*	*SD*
ICS 1	.12	0.97	-.28	1.10	.11	0.98
App Creators	-.57	0.93	.16	0.93	-.46	0.96
ICS 1 and App Creators	.00	1.00	.00	1.00		

Summary of the Findings

Research Question 1: What effect did the revision of a middle school computer science unit of study have on teacher evaluations of course quality?

While teachers consistently rated the revised unit more favorably than the original unit, there was no significant difference between the teachers' ratings based on computer science unit facilitated. This included the subcategories of the student experience, meaningful assessment and feedback, teacher efficacy and support, relevant curriculum aligned to career and post-secondary education, multimedia, and net promoter score. The results of the qualitative portion of the study revealed a trend of teachers heavily modifying the content and delivery of the original unit, ICS 1. Teachers modified the unit to meet student needs as well as scaffold the experience more effectively. The focus group data showed a clear preference by teachers for the App Creators course as compared to Introduction to Computer Science 1. For example, one teacher stated, "I think App Creators is a vast improvement over its predecessor." Teachers reported App Creators offered a much better curriculum than Introduction to Computer Science 1, and "it isn't jumping all over the place as much as the previous course did." Teachers also appreciated the addition of the end of lesson and end of unit assessments the organization added to the revised unit. Additionally, teachers liked the revised unit because they felt their students enjoyed it, were challenged by it and were successful in acquiring new knowledge and skills. However, teachers raised concerns over the emphasis of the biomedical science content and requested more projects related to gaming.

Research Question 2: What effect did the revision of a middle school computer science unit of study have on student evaluations of student engagement?

This study also sought to evaluate the revision of a computer science unit of study on student evaluations of the student experience. The student survey data showed a significant difference between the students' ratings based on computer science unit experienced. This included the subcategories of cognitive engagement, career interest, teamwork and communication skills, and problem-solving. For all of these subgroups, students rated the original unit, Introduction to Computer Science 1 more favorably than the revised unit, App Creators. Similarly, students recommended the original unit significantly more than the revised unit. For both units, students suggested the curriculum be more interesting or fun. However, students in both cohorts expressed interest in creating tablet applications.

Research Question 3: What were the differences between student and teacher evaluations of a middle school computer science unit of study?

The final focus of this study was to consider the differences between student and teacher evaluations of the computer science unit of study. A significant difference was found between student and teacher evaluations of the units. For both computer science units, teachers rated the confidence levels of students significantly higher than students rated the units' effect on confidence. Similarly, teachers rated ownership of learning more favorably than students for both units. This indicated teachers viewed both units as more effective at building student confidence and driving student ownership of their learning than students viewed the units. Additionally, both career readiness and course recommendation showed a significant difference in the interaction between the unit and the group.

Limitations

The primary limitation to this study was the fidelity of implementation of the curriculum. Several teachers from both the survey and focus groups described how they drastically modified and supplemented the ICS 1 curriculum. This calls into question the validity of the student data as to what curriculum they experienced if it was ICS 1 as written or another version greatly modified and enhanced by their teacher due to the course not meeting their expectations in its original form.

Additional threats include the effect of history on the study design. As this was a cohort design, it is possible an outside event influenced the participants' responses over time. One known trend that may have influenced students and teachers is an increased awareness and desire for computer science education. Although participants were advised to consider only the nine-week unit of study when responding, outside influences such as additional programming experiences may have affected the data. Moreover, potential maturation of the teachers' effectiveness in teaching computer science outside of the revisions made to the curriculum could cause students and teachers to rate the course higher than it would perform as written. The risk of maturation was mitigated for this study as both experienced and novice teachers reviewed the units of study and students with both experienced and novice teachers provided feedback.

Furthermore, the curriculum provider facilitated both the surveys and focus groups; this direct involvement may have affected the participants' responses. To minimize this risk, the students and teachers submitted the surveys anonymously and focus group facilitators assured participants their feedback was both confidential and an important input to the continuous improvement of the course; therefore, their direct and honest opinion was valued.

A final limitation of this study was the lack of a pretest for either version of the curriculum. The organization has a set schedule for administering surveys at the end of each semester and is sensitive to over-surveying its network of students and teachers. The organization also does not collect personally identifiable information when administering survey instruments, which prohibit matching the pre- and post-test data by the individual participant.

Implications and Recommendations

The field of computer science has experienced a resurgence of interest in K-12 education largely due to a call for increased focus by key stakeholders in education, government, and workforce development (Fluck et al., 2016; Nager & Atkinson, 2016; Project Lead The Way, 2016; The White House, Office of the Press Secretary, 2016; Wilson et al., 2010). However, the greater part of existing research through 2017 included students primarily at the secondary and post-secondary levels. This study aimed to add to the body of research on middle school computer science education and, specifically, to evaluate the effectiveness of a revised middle school computer science curriculum on teacher and student evaluations of the course, including teacher evaluations of course quality and student evaluations of the student experience.

The primary implications of this study include ensuring the fidelity of curricular implementation and additional research opportunities. Although students rated the original computer science unit significantly more favorably than they rated the revised unit, the qualitative data indicated teachers were heavily modifying the curriculum for the original unit as they were largely unsatisfied with the quality. This calls into question the fidelity of the implementation and evaluation by both students and teachers. Therefore, further research is recommended to evaluate teacher evaluations of course quality and student evaluations of the student experience. Given the indication that many teachers modified the original unit, Introduction to Computer Science 1, a controlled experimental study is recommended to objectively evaluate the curriculum as published by the organization.

An additional implication of this study was students and teachers rated the units differently. This implies that future studies should include feedback from both groups, as the perceptions of the students and teachers are unique. Finally, the results of this study indicate a need for further research into middle school student engagement in computer science education. The current study relied on self-reporting by students regarding engagement. However, classroom observation may provide additional insight into the most and least engaging aspects of the unit to influence future revisions of the content.

Recommendations from this study include suggestions for middle school computer science curriculum providers. The research indicated students prefer opportunities for choice in the type of computer science artifact they design and build. Additionally, curriculum providers are encouraged to provide support for the differentiation of content to provide an appropriate challenge for students with varied ability and reading levels. Overall, the feedback from students and teachers suggested middle school computer science curricula should be approachable and accessible to a variety of students to increase student engagement and provide teachers with effective and usable classroom content.

REFERENCES

Achieve (2015). *Listening to students: Sample focus group and survey materials.* Retrieved from: https://www.achieve.org/files/Achieve_StudentAssessmentInventory_ListeningtoStudents.pdf

Achilles, C. M., Pate Bain, H., Bellott, F., Boyd-Zaharias, J., Finn J., Folger, J., …Word, E. (2008). Tennessee's Student Teacher Achievement Ratio (STAR) project. *Harvard Dataverse*, *1*, Retrieved from https://dataverse.harvard.edu/dataset.xhtml?persistentId=hdl:1902.1/10766

Alano, J., Babb, D., Bell, J., Booker-Dwyer, T., DeLyser, L. A., Dooley, C. M., . . . Weintrop, D. (2016). K–12 Computer Science Framework. *K12 Computer Science*. Retrieved from http://www.k12cs.org.

Amador, J. A., Miles, L., & Peters, C. B. (2006). *The practice of problem-based learning: A guide to implementing PBL in the college classroom.* Boston, MA: Auker.

Angeli, C., Voogt, J., Fluck, A., Webb, M., Cox, M., Malyn-Smith, J., & Zagami, J. (2016). A K-6 computational thinking curriculum framework: Implications for teacher knowledge. *Educational Technology & Society, 19*(3), 47–57.

Bootstrap. (2017). *Computational modeling in algebra, physics, and data science, for all students.* Retrieved from http://www.bootstrapworld.org/

Brennan, K., Balch, C., & Chung, M. (2014). *Creative Computing*. Retrieved from http://scratched.gse.harvard.edu/guide/files/CreativeComputing20141015.pdf

Center for Teaching and Learning. (2001). Problem-based learning. *Stanford University Newsletter on Teaching, 11*(1), 1-8. Retrieved from https://web.stanford.edu/dept/CTL/Newsletter/problem_based_learning.pdf

Code.org. (2017). *Our newest course: CS discoveries.* Retrieved from https://code.org/educate/csd

College Board. (2016). *Number of schools offering AP exams (by subject)*. Retrieved from https://secure-media.collegeboard.org/digitalServices/pdf/research/2016/Number-of-Schools-Offering-AP-2016.pdf

Computer Science Education Week. (2017a). *Third party educator resources.* Retrieved from https://csedweek.org/educate/curriculum/3rd-party

Computer Science Education Week. (2017b). *Third party educator resources: Full details and comparison.* Retrieved https://docs.google.com/spreadsheets/d/1-lbIKCkcVWWTFhcmpZkw8AcGv0iPj-hEqvO0Eu0N1hU/pubhtml?gid=1162176811&single=true

Conner, J. O., & Pope, D. C. (2013). Not just robo-students: Why full engagement matters and how schools can promote it. *Journal of Youth and Adolescence, 42*(9), 1426-42. doi: http://dx.doi.org/10.1007/s10964-013-9948-y

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Boston: Pearson.

Dekhane, S., Xu, X., & Tsoi, M.Y. (2013). Mobile app development to increase student engagement and problem-solving skills. *Journal of Information Systems Education, 24*(4), 299-308.

Denner, J., Werner, L., Campe, S., & Ortiz, E. (2014). Pair programming: Under what conditions is it advantageous for middle school students? *Journal of Research on Technology in Education, 46*(3), 277-296.

Dewey, J. (1916). *Democracy and education: An introduction to the philosophy of education*. New York: Free Press.

Duch, B., Groh, S. E., & Allen, D. E. (eds.). (2001). *The power of problem-based learning: A practical "how-to" for teaching undergraduate courses in any discipline.* Sterling, VA: Stylus.

Eid, C., & Millham, R. (2012). Which introductory programming approach is most suitable for students: Procedural or visual programming? *American Journal of Business Education (Online), 5*(2), 173.

Ernst, J. V., & Clark, A. C. (2012). Fundamental computer science conceptual understandings for high school students using original computer game design. *Journal of STEM Education: Innovations and Research, 13*(5), 40-45.

Finn, J. D., & Zimmer, K. S. (2012). Student engagement: What is it? Why does it matter? In Christenson, S. L., Reschly, A. L., & Wylie, C. (Eds.), *Handbook of research on student engagement*, 97-131. New York: Springer Science and Business Media, LLC. doi 10.1007/978-1-4614-2018-7

Fluck, A., Webb, M., Cox, M., Angeli, C., Malyn-Smith, J., Voogt, J., & Zagami. J. (2016). Arguing for computer science in the school curriculum. *Journal of*

Educational Technology & Society, 19(3), 38-46. Retrieved from http://www.jstor.org/stable/jeductechsoci.19.3.38

Fredricks, J. A., Blumenfeld P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59-109. doi:10.3102/00346543074001059

Gay, L. R. & Mills, G. E. (2016). *Educational research: Competencies for analysis and applications* (11th ed.). Boston: Pearson.

Glaserfeld, E. (2001). *Prospects quarterly review of comparative education, 31*(2). ISSN: 0033-1538

Google-Gallup Partnership. (2015). *Searching for computer science: Access and barriers in U.S. K-12 education.* Retrieved from http://csedu.gallup.com/home.aspx

Grover, S., Pea, R., & Cooper, S. (2016). *Factors Influencing Computer Science Learning in Middle School.* Paper presented at the meeting of the Association for Computing Machinery's Special Interest Group on Computer Science Education (SIGSCE), Retrieved from http://life-slc.org/docs/LSLC_rp_A211_Grover-Pea-Cooper-SIGSCE2016.pdf

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3).

Johnson, L., Adams, S., & Cummins, M. (2012). Mobile apps. *The NMC horizon report: 2012 higher education edition*. Austin, Texas: The New Media Consortium.

Klassen, M. (2006). *Visual approach for teaching programming concepts.* Paper presented at the Proceedings of the 9th International Conference on Engineering Education.

Klem, A. M., & Connell, J. P. (2004). Relationships matter: Linking teacher support to student engagement and achievement. *Journal of School Health, 74*(7), 262–273.

Koc, E., Koncz, A., Tsang, K., Eismann, L., & Longenberger, A. (2017). *Spring Salary Survey: Final starting salaries for class of 2016 new college graduates data reported by colleges and universities.* National Association of Colleges and Employers. (ISSN 1520-8648)

Krauss, J., & Boss, S. (2013). *Thinking through project-based learning: Guiding deeper inquiry.* Thousand Oaks, CA: Corwin.

Lambros, A. (2002). *Problem-based learning in K-8 classrooms.* Thousand Oaks, CA: Corwin.

Lee, I. (2016). Reclaiming the roots of CT. *CSTA Voice: The Voice of K–12 Computer Science Education and Its Educators*, *12*(1), 3–4.

Lewis, A. D, Huebner, E. S., Malone, P. S., & Valois, R. F. (2011). Life Satisfaction and Student Engagement in Adolescents. *Journal of Youth Adolescence, 40*, 249–262. doi 10.1007/s10964-010-9517-6

Mahatmya, D., Lohman, B. J., Matjasko, J. L., & Fedman Farb, A. (2012). Engagement across developmental periods. In Christenson, S. L., Reschly, A. L., & Wylie, C. (Eds.), *Handbook of research on student engagement*, 45-64. New York: Springer Science and Business Media, LLC. doi 10.1007/978-1-4614-2018-7

Maltese, A. V., & Tai, R. H. (2010). Eyeballs in the fridge: Sources of early interest in science. *International Journal of Science Education*, *5*(32), 669-685.

Massachusetts Department of Elementary and Secondary Education. (2016). *Massachusetts digital literacy and computer science (DLCS) curriculum* *framework.* Malden, MA: Author. Retrieved from http://www.doe.mass.edu/frameworks/dlcs.pdf

Mihci, C., & Ozdener Donmez, N. (2017). Teaching GUI-programming concepts to prospective K12 teachers: MIT app inventor as an alternative to text based languages. *International Journal of Research in Education and Science (IJRES), 3*(2), 543-559. doi:10.21890/ijres.327912

Montero, I., & León, O. (2007). A guide for naming research studies in Psychology. *International Journal of Clinical and Health Psychology, 7*(3), 847-862.

Montoya, A. (2017). Computer science for all: Opportunities through a diverse teaching workforce. *Harvard Journal of Hispanic Policy, 29*, 47-62.

Nager, A., & Atkinson, R. D. (2016). *The case for improving U.S. computer science education.* Information Technology & Innovation Foundation. Retrieved from www.itif.org

National Center for Women and Information Technology. (2017). *NCWIT fact sheet*. Retrieved from: https://www.ncwit.org/ncwit-fact-sheet

National Research Council, Policy and Global Affairs, & Board on Global Science and Technology. (2012). *New global ecosystem in advanced computing* National Academies Press. Retrieved from http://replace-me/ebraryid=10863945

National Research Council. (2009). *Strengthening High School Chemistry Education through Teacher Outreach Programs: A Workshop Summary to the Chemical Sciences Roundtable.* Washington DC: Author.

Papert, S. (1980). *Mindstorms. Children, computers, and powerful ideas*. New York: Basic Books.

Papert, S. (2000). What's the big idea? Toward a pedagogy of idea power. *IBM Systems Journal*, *39*(3 & 4), 720–729.

Perkins, D. N. (1991). What constructivism demands of the learner. *Educational Technology*, *31*, 18-23.

Phillips, P., (Ed.). (2012). *Computer science K-8* [Special Issue]. Computer Science Teachers Association and the Association for Computing Machinery. Retrieved from http://csta.hosting.acm.org/csta/csta/Curriculum/sub/CurrFiles/CS_K-8_Building_a_Foundation.pdf

Piaget, J. (1969). *Science of education and the psychology of the child.* New York: Viking.

Pike, G., & Robbins, K. (2014). *Using Propensity Scores to Evaluate Education Programs.* Indiana: Indiana University-Purdue University-Indianapolis.

Pokress, S. C., & Veiga, J. D. D. (2013). Enabling personal mobile computing. *MIT App Inventor*. Retrieved from http://appinventor.mit.edu/explore/stories.html

Project Lead The Way. (2016). *Teacher as a facilitator of learning.* Unpublished work.

Project Lead The Way. (2017a). *About us*. Retrieved from www.pltw.org

Project Lead The Way. (2017b). *Accelerating college and career readiness: Integration of AP and Project Lead The Way at Francis Tuttle Technology Center.* Retrieved from https://www.pltw.org/francis-tuttle-case-study

Project Lead The Way. (2017c). *APB Workshop: Building a deeper understanding* [PowerPoint slides]. Workshop presented at the Project Lead The Way National Summit, Orlando, FL.

Project Lead The Way. (2017d). *App Creators*. Glossary. Retrieved from https://pltw.read.inkling.com

Project Lead The Way. (2017e). *Ensuring high levels of learning for all: AP + Project Lead The Way in star city school district.* Retrieved from https://www.pltw.org/star-city-case-study

Project Lead The Way. (2017f). *PLTW Curriculum Theory of Action: How PLTW Curriculum inspires all students to thrive in an evolving world.* Unpublished work.

Project Lead The Way. (2017g). *PLTW Gateway*. Retrieved from https://www.pltw.org/our-programs/pltw-gateway

Project Lead The Way. (2017h). *Project Lead The Way Implementation guide*. Retrieved from https://www.pltw.org/implementation-guide

Project Lead The Way. (2017i). *Project Lead The Way students take STEM and entrepreneurship to new places*. Retrieved from https://www.pltw.org/gulliver-prep-case-study

Project Lead The Way. (2017j). *The APB instructional approach.* Unpublished work.

Project Lead The Way. (2017k). *PLTW Curriculum Theory of Action: How PLTW Curriculum inspires all students to thrive in an evolving world.* Unpublished work.

Project Lead The Way. (2017l). *PLTW Gateway*. Retrieved from https://www.pltw.org/our-programs/pltw-gateway

Project Lead The Way. (2017m). *Topline High School Student Engagement Results* [PowerPoint slides]. Presented at the May 2017 Senior Leadership Business and Operations Meeting, Indianapolis, IN.

Project Lead The Way. (2018). *Curriculum and professional development instructional principles: The definitive instructional approach to PLTW teaching and learning.* Unpublished work.

Rethwisch, D. (2014). *A Study of the Impact of Project Lead The Way on Achievement Outcomes in Iowa.* The 2014 ASEE North Midwest Section Conference, Iowa City, IA., October 16-17, 2014.

Richards, E., & Terkanian, D. (2013). Occupational employment projections to 2022. *Monthly Labor Review,* U.S. Bureau of Labor Statistics. doi: 10.21916

Rowan-Kenyon, H., Swan, A. K., & Creager, M. F. (2012). Social cognitive factors, support, and engagement: Early adolescents' math interests as precursors to choice of career. *The Career Development Quarterly, 60*(1), 2-15. Retrieved from http://0-search.proquest.com.library.trevecca.edu/docview/940864840?accountid=29083

Salkind, N. J. (2017). *Statistics for People Who (Think They) Hate Statistics* (6th ed.). Thousand Oaks: Sage Publications.

Shin, N., Jonassen, D. H., & McGhee, S. (2003). Predictors of well-structured and ill-structured problem solving in an astronomy simulation. *Journal of Research in Science Teaching, 40*(1), 6-33. doi: 10.1002/tea.10058

Sorge, B. H. (2014). *A multilevel analysis of project leads the way implementation in Indiana* (Order No. 3702102). Available from ProQuest Dissertations & Theses

Global. (1681362996). Retrieved from http://0-search.proquest.com.library.trevecca.edu/docview/1681362996?accountid=29083

Stanton, J., Goldsmith, L., Adrion, W., Dunton, S., Hendrickson, K., Peterfreund, A., . . . Dounay Zinth, J. (2017). *State of the states landscape report: State-level policies supporting equitable K-12 computer science education.* BNY Mellon. Retrieved from http://www.ecs.org/ec-content/uploads/MassScan-Full-Report-v10.pdf

Stohlmann, M., Moore, T. J., McClelland, J., & Roehrig, G. H. (2011). Impressions of a middle grades STEM integration program. *Middle School Journal, 43*(1), 32-40.

Tai, R. H. (2012). *An Examination of Research Literature on PLTW.* University of Virginia. Publication by PLTW.

The White House, Office of the Press Secretary. (2016). *Fact sheet: President Obama announces computer science for all initiative* [Press release]. Retrieved from https://www.whitehouse.gov/the-press-office/2016/01/30/fact-sheet-president-obama-announces-computer-science-all-initiative-0

The White House, Office of the Press Secretary. (2017). *Presidential memorandum for the Secretary of Education.* [Press release]. Retrieved from https://www.whitehouse.gov/the-press-office/2017/09/25/memorandum-secretary-education

Tucker, A., McCowan, D., Deek, F., Stephenson, C., Jones, J., & Verno, A. (2006*). A model curriculum for K–12 computer science: Report of the ACM K–12 task force curriculum committee* (2nd ed.). New York, NY: Association for Computing Machinery.

U.S. Bureau of Labor Statistics Office of Occupational Statistics and Employment Projections. (2015). *Computer and Information Technology Occupations.* Retrieved from http://www.bls.gov/ooh/computer-and-information-technology/home.htm

UC Davis (2017). *C-STEM Middle School Curriculum.* UC Davis C-STEM Center. Retrieved from http://c-stem.ucdavis.edu/curriculum/middle-school/

Van Overschelde, J. P. (2013). Project Lead The Way Students more prepared for higher education. *American Journal of Engineering Education, 4*(1).

Voicheck, M. G. (2012). *High school pre-engineering program graduates' perceptions of Project Lead The Way courses and technological literacy* (Unpublished doctoral dissertation). Pennsylvania: Immaculate University.

Voogt, J., Fisser, P., Good, J., Mishra, P., & Yadav, A. (2015). Computational thinking in compulsory education: Towards an agenda for research and practice. *Education and Information Technologies, 20*(4), 715-728. doi:http://dx.doi.org/10.1007/s10639-015-9412-6

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University.

Webb, M., Fluck, A., Cox, M., Angeli-Valanides, C., Malyn-Smith, J., Voogt, J., & Zagami, J. (2015). Curriculum: Advancing understanding of the roles of computer science/informatics in the curriculum. In K. W. Lai (Ed.), *EDUsummIT 2015 Summary Report* (pp. 61-70). Retrieved from http://www.curtin.edu.au/edusummit/local/docs/edusummit2015-ebook.pdf

Wiggins, G., & McTighe, J. (2011). *The Understanding by Design Guide to Creating High-Quality Units.* Alexandria, Virginia: ASCD.

Wilson, C., Sudol, L. A., Stephenson, C., & Stehilk, M. (2010). *Running on empty: The failure to teach K-12 computer science in the digital age.* Association for Computing Machinery. Retrieved from http://runningonempty.acm.org/

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33-35.

Yadav, A., Hong, H., & Stephenson, C. (2016). Computational thinking for all: Pedagogical approaches to embedding 21st-century problem solving in K-12 classrooms. *TechTrends, 60*(6), 565-568. doi:http://dx.doi.org/10.1007/s11528-016-0087-7

Appendix A

Teacher Survey 2017

PLTW Teacher Survey 2017 - Gateway Units

Project Lead The Way is committed to delivering a student experience that is engaging, relevant, and challenging. Your perception of how we're doing is key to helping us to create and deliver a better learning experience to all students.

The survey will take 10-15 minutes and your responses will be confidential and anonymous.

The intent for the survey is to gather your feedback at the specific unit level. Therefore, if you teach more than one unit you will have the opportunity to more than on survey. Please look for more information at the end of the survey. We understand time is a valuable resource, so if you are teaching more than one unit this year and are unable to complete more than one survey, please choose the one you would like to share your feedback about the most.

Thanks for your time!

PLTW Teacher Survey 2017 - Gateway Units

1. Please select the PLTW Gateway unit you are providing feedback for:

- ◯ Design and Modeling
- ◯ Automation and Robotics
- ◯ Introduction to Computer Science I
- ◯ Introduction to Computer Science II
- ◯ Energy and the Environment
- ◯ Flight and Space
- ◯ Science of Technology
- ◯ Magic of Electrons
- ◯ Green Architecture
- ◯ Medical Detectives

PLTW Teacher Survey 2017 - Gateway Units

2. What version of Design and Modeling unit are you teaching this year?

- New Design and Modeling (Unit Problem: Design a therapeutic toy for a child with cerebral palsy)
- Design and Modeling (Unit Problem: Design a new playground for the elementary school)

PLTW Teacher Survey 2017 - Gateway Units

Student Experience

In this section, we would like to know about your students' experience with the course.

3. Please state the degree to which you agree or disagree with the following statements.
In this course, students:

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
Demonstrate creativity.					
Use relevant industry tools and technology.					
Overcome setbacks and failure as part of learning.					
Gain confidence in their knowledge, skills, and abilities.					
Are eager to learn more about course topics on their own.					
Are likely to take ownership of their own learning.					

PLTW Teacher Survey 2017 - Gateway Units

Student Experience

4. The learning in this unit is developmentally appropriate for middle school students.

- Strongly Disagree
- Disagree
- Neither Agree or Disagree
- Agree
- Strongly Agree

5. The learning in this unit is appropriately challenging for middle school students.

- Strongly Disagree
- Disagree
- Neither Agree or Disagree
- Agree
- Strongly Agree

PLTW Teacher Survey 2017 - Gateway Units

Assessment

6. Please rate the overall level of support/guidance provided on how to use formative and summative assessment to better your instruction?

- Very Poor
- Poor
- Good
- Very Good
- Excellent

7. Did you use the assessment materials available in the curriculum and teacher resources this school year? Materials may include pre-assessments, student self-evaluation and reflection tools and formative assessment.

- Yes
- No, although I do know what those are and where to find them
- No, could not access and/or did not know where to find them
- Don't know / don't remember

PLTW Teacher Survey 2017 - Gateway Units

Assessment

8. How adequate did you find each of the following assessment materials?

	1 - Not at All Adequate	2	3	4	5 - Extremely Adequate
Pre-assessments for the lesson.					
Opportunities for student self-evaluation and reflection.					
Interim assessments throughout the unit.					
Formative assessment strategies embedded in the curriculum.					
Formative assessment strategies embedded in the teacher resources.					
Summative assessment at the end of the unit.					

PLTW Teacher Survey 2017 - Gateway Units

Facilitator Role

9. Please state the degree to which you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
I know the steps to teach this unit effectively.	◯	◯	◯	◯	◯
I wonder whether I have the necessary skills to teach this unit.	◯	◯	◯	◯	◯
I understand course concepts well enough to be effective in facilitating this unit.	◯	◯	◯	◯	◯
I have the knowledge of assessment that I need to facilitate this class well.	◯	◯	◯	◯	◯
I would like to gain more content knowledge as it relates to this unit.	◯	◯	◯	◯	◯
I regularly use a variety of questioning techniques as a facilitation strategy.	◯	◯	◯	◯	◯
I am confident in using the PLTW Activity-Project-Problem learning strategy.	◯	◯	◯	◯	◯
I have the knowledge I need to differentiate the material in this unit to meet the needs of all students.	◯	◯	◯	◯	◯

PLTW Teacher Survey 2017 - Gateway Units

Facilitator Support and Materials

10. How satisfied are you with the support provided by PLTW on each of the dimensions below?

	Not At All Satisfied	Not Very Satisfied	Somewhat Satisfied	Very Satisfied	Extremely Satisfied
Teacher resource and reference materials.	◯	◯	◯	◯	◯
Ability to collaborate with and learn from other PLTW teachers.	◯	◯	◯	◯	◯
The PLTW ongoing training.	◯	◯	◯	◯	◯

PLTW Teacher Survey 2017 - Gateway Units

Content

11. Thinking about the content of the unit, indicate how frequently each of the following occur.
The content of the unit...

	Never	Occasionally	About Half the Time	Usually	Always
Aligns to learning outcomes that my administration values.	◯	◯	◯	◯	◯
Is accurate.	◯	◯	◯	◯	◯
Is up to date and current.	◯	◯	◯	◯	◯
Allows an appropriate amount of time for deep learning.	◯	◯	◯	◯	◯
Prepares students with skills that employers seek.	◯	◯	◯	◯	◯
Prepares students with skills that post-secondary institutions seek.	◯	◯	◯	◯	◯
Prepares students with in-demand, transportable skills for long-term success in life and career.	◯	◯	◯	◯	◯
Is free of bias and stereotypes.	◯	◯	◯	◯	◯

12. Have you made any changes or modifications to this unit?

- I make changes to nearly every lesson or module.
- I occasionally will change something within a lesson or module.
- I very rarely make changes to lessons or modules in this unit.
- I haven't made any changes.

13. Why did you - or did you not - make changes to this unit?

PLTW Teacher Survey 2017 - Gateway Units

Content

14. Focus on the multimedia content included in the unit, which may consist of videos, simulations, illustrations, photos. Please indicate the degree to which you agree or disagree with each of the following statement.

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
The multimedia feels current and cutting-edge.					
The unit contains multimedia that is engaging.					
Contains multimedia that is appropriate in length.					
The multimedia delivery is appropriate for students' developmental level.					

PLTW Teacher Survey 2017 - Gateway Units

Overall Impressions

15. How likely is it that you would recommend this unit to a friend or colleague?

Not at all likely — Extremely likely

0	1	2	3	4	5	6	7	8	9	10

16. Overall, how satisfied are you with this unit?

Not At All Satisfied	Not Very Satisfied	Somewhat Satisfied	Very Satisfied	Extremely Satisfied
○	○	○	○	○

17. What changes would PLTW have to make for you to give it a higher rating?

18. Please include any additional comments you would like to share regarding your PLTW experience.

PLTW Teacher Survey 2017 - Gateway Units

19. What grade(s) are you teaching this course?

- ☐ 6th
- ☐ 7th
- ☐ 8th
- ☐ Other (please specify)

20. How many years have you taught this unit?

- ○ This is my first year
- ○ 2-3 years
- ○ 4-5 years
- ○ 6-10 years
- ○ More than 10 years

21. Have you taught another PLTW unit prior to teaching this one?

- ◯ Yes
- ◯ No

22. Please select your state

23. Which of the following describe(s) your school?

- ◯ Traditional Public
- ◯ Public Charter
- ◯ Private
- ◯ Other (please specify)

24. Which of the following best describes the area or setting of your school?

- ◯ Rural
- ◯ Urban/City Area
- ◯ Suburban
- ◯ Other (please specify)

25. What relevant subject matter license(s) you hold?

- [ ] Engineering
- [ ] Science
- [ ] Math
- [ ] Physical Science
- [ ] Chemistry
- [ ] Life Science
- [ ] Earth Science
- [ ] Business
- [ ] Career and Technical Education
- [ ] Computer Science
- [ ] Other (please specify)

Appendix B

Teacher Survey 2018

PLTW Gateway Teacher Survey 2017-2018

Project Lead The Way is committed to delivering a student experience that is engaging, relevant, and challenging. Your perception of how we're doing is key to helping us to create and deliver a better learning experience to all students.

The survey will take 10-15 minutes and your responses will be confidential and anonymous.

The intent for the survey is to gather your feedback at the specific unit level. Therefore, if you teach more than one unit you will have the opportunity to respond to more than one survey. Please look for more information at the end of the survey. We understand time is a valuable resource, so if you are teaching more than one unit this year and are unable to complete more than one survey, please choose the one you would like to share your feedback about the most.

Thanks for your time!

PLTW Gateway Teacher Survey 2017-2018

* 1. Please select the PLTW Gateway unit you are providing feedback for:

- Design and Modeling
- Automation and Robotics
- Introduction to Computer Science I
- Introduction to Computer Science II
- Energy and the Environment
- Flight and Space
- Science of Technology
- Magic of Electrons
- Green Architecture
- Medical Detectives
- Innovators and Makers
- App Creators

PLTW Gateway Teacher Survey 2017-2018

PLTW Gateway Teacher Survey 2017-2018

Student Experience

In this section, we would like to know about your students' experience with the course.

* 2. Please state the degree to which you agree or disagree with the following statements.
In this course, students:

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
Demonstrate creativity.	○	○	○	○	○
Use relevant industry tools and technology.	○	○	○	○	○
Overcome setbacks and failure as part of learning.	○	○	○	○	○
Gain confidence in their knowledge, skills, and abilities.	○	○	○	○	○
Are eager to learn more about course topics on their own.	○	○	○	○	○
Are likely to take ownership of their own learning.	○	○	○	○	○
This course is written at an appropriate developmental level.	○	○	○	○	○

PLTW Gateway Teacher Survey 2017-2018

Student Experience

PLTW Gateway Teacher Survey 2017-2018

Assessment

* 3. Please rate the overall level of support/guidance provided on how to use formative and summative assessment to better your instruction?

- Very Poor
- Poor
- Good
- Very Good
- Excellent

* 4. Did you use the assessment materials available in the curriculum and teacher resources this school year? Materials may include pre-assessments, student self-evaluation and reflection tools and formative assessment.

- Yes
- No, although I do know what those are and where to find them
- No, could not access and/or did not know where to find them
- Don't know / don't remember

PLTW Gateway Teacher Survey 2017-2018

Assessment

* 5. How adequate did you find each of the following assessment materials?

	1 - Not at All Adequate	2	3	4	5 - Extremely Adequate
Opportunities for student self-evaluation and reflection.					
Interim assessments throughout the unit.					
Formative assessment strategies embedded in the curriculum.					
Formative assessment strategies embedded in the teacher resources.					
Summative assessment at the end of the unit.					

PLTW Gateway Teacher Survey 2017-2018

Facilitator Role

* 6. Please state the degree to which you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
I know the steps to teach this unit effectively.	◯	◯	◯	◯	◯
I wonder whether I have the necessary skills to teach this unit.	◯	◯	◯	◯	◯
I understand course concepts well enough to be effective in facilitating this unit.	◯	◯	◯	◯	◯
I have the knowledge of assessment that I need to facilitate this class well.	◯	◯	◯	◯	◯
I would like to gain more content knowledge as it relates to this unit.	◯	◯	◯	◯	◯
I regularly use a variety of questioning techniques as a facilitation strategy.	◯	◯	◯	◯	◯
I am confident in using the PLTW Activity-Project-Problem learning strategy.	◯	◯	◯	◯	◯
I have the knowledge I need to differentiate the material in this unit to meet the needs of all students.	◯	◯	◯	◯	◯

PLTW Gateway Teacher Survey 2017-2018

Facilitator Support and Materials

* 7. How satisfied are you with the support provided by PLTW on each of the dimensions below?

	Not At All Satisfied	Not Very Satisfied	Somewhat Satisfied	Very Satisfied	Extremely Satisfied
Teacher resource and reference materials.	◯	◯	◯	◯	◯
Ability to collaborate with and learn from other PLTW teachers.	◯	◯	◯	◯	◯
The PLTW ongoing training.	◯	◯	◯	◯	◯

PLTW Gateway Teacher Survey 2017-2018

Content

* 8. Thinking about the content of the unit, indicate how frequently each of the following occur.
The content of the unit...

	Never	Occasionally	About Half the Time	Usually	Always
Aligns to learning outcomes that my administration values.	◯	◯	◯	◯	◯
Is accurate.	◯	◯	◯	◯	◯
Is up to date and current.	◯	◯	◯	◯	◯
Allows an appropriate amount of time for deep learning.	◯	◯	◯	◯	◯
Prepares students with skills that employers seek.	◯	◯	◯	◯	◯
Prepares students with skills that post-secondary institutions seek.	◯	◯	◯	◯	◯
Prepares students with in-demand, transportable skills for long-term success in life and career.	◯	◯	◯	◯	◯
Is free of bias and stereotypes.	◯	◯	◯	◯	◯

* 9. Have you made any changes or modifications to this unit?

- I make changes to nearly every lesson or module.
- I occasionally will change something within a lesson or module.
- I very rarely make changes to lessons or modules in this unit.
- I haven't made any changes.

10. Why did you - or did you not - make changes to this unit?

PLTW Gateway Teacher Survey 2017-2018

Content

* 11. Focus on the multimedia content included in the unit, which may consist of videos, simulations, illustrations, photos. Please indicate the degree to which you agree or disagree with each of the following statement.

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
The multimedia feels current and cutting-edge.					
The unit contains multimedia that is engaging.					
Contains multimedia that is appropriate in length.					
The multimedia delivery is appropriate for students' developmental level.					

PLTW Gateway Teacher Survey 2017-2018

Overall Impressions

* 12. How likely is it that you would recommend this unit to a friend or colleague?

Not at all likely | Extremely likely

0	1	2	3	4	5	6	7	8	9	10

13. What changes would PLTW have to make for you to give it a higher rating?

PLTW Gateway Teacher Survey 2017-2018

* 14. What grade(s) are you teaching this course?

- [ ] 6th
- [ ] 7th
- [ ] 8th
- [ ] Other (please specify)

* 15. How many years have you taught this unit?

- ( ) This is my first year
- ( ) 2-3 years
- ( ) 4-5 years
- ( ) 6-10 years
- ( ) More than 10 years

* 16. Have you taught another PLTW unit prior to teaching this one?

- ( ) Yes
- ( ) No

* 17. What is the highest level of school you have completed or the highest degree you have reached?

- Associates degree
- Bachelors degree
- Masters degree
- Ed. S.
- Ph.D., Ed.D or Professional Degree

* 18. Please select your state

* 19. Which of the following describe(s) your school?

- Traditional Public
- Public Charter
- Private
- Other (please specify)

* 20. Which of the following best describes the area or setting of your school?

- Rural
- Urban/City Area
- Suburban
- Other (please specify)

* 21. What relevant subject matter license(s) you hold?

- [ ] Engineering
- [ ] Science
- [ ] Math
- [ ] Physical Science
- [ ] Chemistry
- [ ] Life Science
- [ ] Earth Science
- [ ] Business
- [ ] Career and Technical Education
- [ ] Computer Science
- [ ] Other (please specify)

Appendix C

Student Survey 2017 & 2018

Project Lead The Way Student Survey

Instructions:

Please complete the following survey. Answer each question keeping in mind the class for which you have been asked to take this survey.

The purpose of this survey is to help Project Lead The Way (PLTW), the organization that helped create this class, understand students' opinions. Responses will be confidential, anonymous, and your individual responses will not be shared with your teacher. Results will **not** be used to grade or evaluate you, your teacher, or your school.

Thank you for participating in our survey. Your feedback is important.

1. This class has allowed me to solve interesting problems.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

2. I think what I have learned in this class will help me in a job someday.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

3. I wish more of my classes were like this one.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

4. I worked with classmates to solve a hard problem in this class.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

5. There were problems in this class that if I did not get the right answer the first time, I tried again until I did get the right answer.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

6. I think this class will help me take on challenging problems in the future.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

7. In this class, I got to explain a new idea to my classmates or my teacher.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

8. This class has helped me become more interested in my own learning.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

9. I found myself to be more focused in this class compared to most of my other classes.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

10. Compared to what I learn in my other classes, I think what I learned in this class will be more helpful in my future career.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

11. I am interested in a career that would allow me to use what I learned in this class.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

12. While working on a team in this class, I was able to work with a classmate even if I disagreed with his or her idea.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

13. I am better able to communicate with my peers because of this class.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

14. I worked harder in this class than I do in most of my other classes.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

15. I was excited when I found out I would be taking this class.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

16. The problems and activities in this class covered topics that matter to me.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

17. This class influenced my plans for after high school.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

18. I would recommend taking this class to a friend.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

19. In this class, I had the chance to help a classmate solve a difficult problem.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

20. I believe this class helped me become a better problem solver.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

21. This class has improved my ability to learn from my mistakes.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

22. I like being at school on days when I have this class more than on days when I don't.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

23. In this class, I became better at listening to and understanding other people explain their point of view.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

24. The information in this class is more important for me to learn than the information I learn in most of my other classes.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

25. The problem-solving skills I've learned in this class will help me in future classes.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

26. I would like to take a class like this one again in the future.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

27. In this class, I had a classmate help me solve a difficult problem.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

28. Compared to tests in my other classes, the tests in this class did a better job of measuring what I'm able to do.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

29. In this class, I learned at least one new way to share an idea with a classmate.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

30. This class helped me gain confidence to overcome challenges.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

31. I think I will be able to use what I learned in this class in other classes.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

32. This class has helped me learn to enjoy challenging problems.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

33. This class has taught me skills I have not had the opportunity to learn in other classes.

◯ Strongly Disagree ◯ Disagree ◯ Neither disagree nor agree ◯ Agree ◯ Strongly Agree

34. Please select the top four statements that you think are true of this class but not most of your other classes:

- ☐ This class has more opportunities to work as a team with my classmates.
- ☐ In this class, I got to learn things that I think will help me in a job someday.
- ☐ This class gave me the chance to develop as a leader.
- ☐ This class gave me the chance to improve my communication skills.
- ☐ The problems and activities in this class were easy.
- ☐ I learned new problem solving skills in this class.
- ☐ I was motivated to work hard in this class.
- ☐ This class was boring.
- ☐ This class has improved my ability to learn from my mistakes.
- ☐ There were problems in this class that if I did not reach the right answer the first time, I tried again until I did get the right answer.
- ☐ The topics we covered in this class don't seem very important to me.

35. Please select the top four statements that you think are true of most of your other classes but not this class:

- ☐ My other classes have more opportunities to work as a team with my classmates.
- ☐ In my other classes, I got to learn things that I think will help me in a job someday.
- ☐ My other classes give me the chance to develop as a leader.
- ☐ My other classes gave me the chance to improve my communication skills.
- ☐ The problems and activities in my other classes are easy.
- ☐ I learn new problem solving skills in my other classes.
- ☐ I am motivated to work hard in my other classes.
- ☐ My other classes are boring.
- ☐ My other classes improved my ability to learn from my mistakes.
- ☐ There are problems in my other classes that if I did not reach the right answer the first time, I tried again until I did get the right answer.
- ☐ The topics we cover in most of my other classes don't seem very important to me.

36. What do you think will be your biggest benefit from taking this class?

37. If you could change anything about this class, what would you change?

38. What else would you like us to know?

39. What is the complete name of the school you attend? If you are not sure, please ask your teacher.

40. What is the complete name of the district the school you attend is part of? If you are not sure, please ask your teacher.

41. What is the name of the city where the school you attend is located? If you are not sure, please ask your teacher.

42. What state is the school you attend located in?

43. Please select your current grade in school:

44. Which of the following was the focus of this class? If you are not sure, please ask your teacher.

- Engineering
- Biomedical Science
- Computer Science

45. What is the name of the class that you took this survey for? If you are not sure, please ask your teacher.

46. What is the name of the class that you took this survey for? If you are not sure, please ask your teacher.

47. What is the name of the class that you took this survey for? If you are not sure, please ask your teacher.

48. What is the name of the class that you took this survey for? If you are not sure, please ask your teacher.

49. Which of the following was the focus of this class? If you are not sure, please ask your teacher.

- Engineering
- Biomedical Science
- Computer Science

50. Have you taken Project Lead The Way (PLTW) classes in the past?

51. If you have you taken Project Lead The Way (PLTW) classes in the past, how many have you taken?

52. Are you currently enrolled in more than one Project Lead The Way (PLTW) class?

53. Please select the option that best describes you:

54. (Optional) Do you speak a language other than English at home?

55. (Optional) To which racial or ethnic group do you most identify?

56. (Optional) To which gender identity do you most identify?

Appendix D

Disaggregated Subgroups by Survey Question

Cognitive Engagement:

Questions in this set are designed to measure cognitive engagement - the dimension of engagement found in literature most closely aligned to PLTW's approach. Cognitive engagement is defined as "the student's level of investment in learning; it includes being thoughtful and purposeful in the approach to school tasks and being willing to exert the effort necessary to comprehend complex ideas or master difficult skills" (Fredricks, Blumenfeld, & Paris, 2004).

1. This class has allowed me to solve interesting problems.
2. I think what I have learned in this class will help me in a job someday.
3. I think this class will help me take on challenging problems in the future.
4. This class has helped me become more interested in my own learning.
5. Compared to what I learn in my other classes, I think what I learn in this class will be more helpful in my future career.
6. The problems and activities in this class covered topics that matter to me.
7. I would recommend taking this class to a friend.
8. I believe this class helped me become a better problem solver.
9. This class has improved my ability to learn from my mistakes.
10. In this class, I became better at listening to and understanding other people explain their point of view.
11. The information in this class is more important for me to learn than the information I learn in most of my other classes.
12. The problem-solving skills I've learned in this class will help me in future classes.
13. Compared to tests in my other classes, the tests in this class did a better job of measuring what I'm able to do.
14. I think I will be able to use what I learned in this class in other classes.
15. This class has helped me learn to enjoy challenging problems.
16. This class has taught me skills I have not had the opportunity to learn in other classes.

Career Interest:

Questions in this set focus on whether or not and to what extent survey participants found their experience in the PLTW course to be relevant to their current interests and future career. Reactions to statements such as, "I think what I have learned in this class will help me in a job someday," are included in this set.

1. This class has allowed me to solve interesting problems.
2. I think what I have learned in this class will help me in a job someday.
3. Compared to what I learn in my other classes, I think what I learned in this class will be more helpful in my future career.
4. I am interested in a career that would allow me to use what I learned in this class.
5. The problems and activities in this class covered topics that matter to me.
6. This class influenced my plans for after high school.
7. The information in this class is more important for me to learn than the information I learn in most of my other classes.
8. The problem-solving skills I've learned in this class will help me in future classes.
9. I think I will be able to use what I learned in this class in other classes.

Team Work and Communication Skills:

Questions in this set are designed to measure the PLTW experience relative to opportunities to work with a team and communicate complex ideas.

1. I worked with classmates to solve a hard problem in this class.
2. In this class, I got to explain a new idea to my classmates or my teacher.

3. While working on a team in this class, I was able to work with a classmate even if I disagreed with his or her idea.
4. I am better able to communicate with my peers because of this class.
5. In this class, I had the chance to help a classmate solve a difficult problem.
6. In this class, I became better at listening to and understanding other people explain their point of view.
7. In this class, I had a classmate help me solve a difficult problem.
8. In this class, I learned at least one new way to share an idea with a classmate.

Problem Solving:
Questions in this set focus on the relationship between survey participants' experiences in the PLTW course and skills and opinions related to problem solving.

1. I think this class will help me take on challenging problems in the future.
2. I believe this class helped me become a better problem solver.
3. This class has improved my ability to learn from my mistakes.

Appendix E

Teacher Voluntary Participation Agreement

TEACHER VOLUNTARY PARTICIPATION AGREEMENT

As a teacher in a Project Lead The Way (PLTW) participating program, you been invited to participate in a research study conducted through Trevecca Nazarene University and PLTW. The decision to participate, or not participate, is completely your decision, and no penalties or loss of special benefits beyond the benefit identified below will occur based on a decision to not participate. The sole benefit to participating teachers is that their participation will help PLTW and the Researcher at Trevecca Nazarene University improve computer science curriculum for both the participating teachers and future teachers and students who teach and take PLTW computer science.

In this research study, we are comparing student and teacher evaluations of two computer science courses. Your will be asked to take part in a focus group with other teachers. The focus group is designed to take approximately 60 minutes. The focus group will involve a facilitator or facilitators, asking questions and memorializing and/or recording the teacher responses. Individually identifying information will not be utilized in the final research product, and no risk greater than those experienced in ordinary conversation are anticipated. Even after the focus group begins discussion, you can stop participating at any time. Specifically, neither your name nor your school name will be used when data from this study are published.

Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

______________________________ ________________________

Teacher Name (printed) School Name

______________________________ ________________________

Signature Date

Appendix F

Student Voluntary Participation Agreement & Parent/Guardian Consent

STUDENT VOLUNTARY PARTICIPATION AGREEMENT

As a student in a Project Lead The Way (PLTW) computer science program, you been invited to participate in a research study conducted through Trevecca Nazarene University and PLTW. The decision to participate, or not participate, is completely your decision along with your parent/guardian's consent and approval, and no penalties or loss of special benefits beyond the benefit identified below will occur based on a decision to not participate. The sole benefit to participating students is that their participation will help PLTW and the Researcher at Trevecca Nazarene University improve computer science curriculum for both the participating students and future students who teach and take PLTW computer science.

In this research study, we are comparing student and teacher evaluations of two computer science courses. Your will be asked to take part in a focus group with other students. The focus group is designed to take approximately 60 minutes. The focus group will involve two adults, both licensed teachers and PLTW employees, asking questions and memorializing and/or recording the student responses. Individually identifying information will not be utilized in the final research product, and no risk greater than those experienced in ordinary conversation are anticipated. Even after the focus group begins discussion, you can stop participating at any time. Specifically, neither your name nor your teacher's or school's names will be used when data from this study are published.

As mentioned in the first paragraph, declining to participate in this study will have no effect on your participation in the PLTW Summit. Further, anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

✓ **Yes, I would like to participate in this research study and have signed my name below. In addition, I have obtained my guardian/parent's consent below.**

__________________________ __________________________

Student Name School

PARENT/GUARDIAN CONSENT

Your child has been invited to participate in a research study conducted through Trevecca Nazarene University and Project Lead The Way (PLTW). The decision to let your child participate, or not participate, is completely your decision, and no penalties or loss of special benefits beyond the benefit identified below will occur based on a decision to not have your child participate. The sole benefit to participating students is that their participation will help PLTW and the Researcher at Trevecca Nazarene University improve computer science curriculum for both the participating students and future students who take computer science.

In this research study, we are comparing student and teacher evaluations of two computer science courses. Your child will be asked to take part in a focus group with other students. The focus group is designed to take approximately 60 minutes. The focus group will involve two adults, both licensed teachers and PLTW employees, asking questions and memorializing and/or recording the student responses. Individually identifying information will not be utilized in the final research product, and-no risk greater than those experienced in ordinary conversation are anticipated. Even after the focus group begins discussion, your child can stop participating at any time. Specifically, neither your child's name nor school will be used when data from this study are published.

As mentioned in the first paragraph, declining to have your child participate in this study will have no effect on your child's participation in the PLTW Summit. Further, anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

__________________________ ____________________

Student Name School Name

__________________________ ____________________

Parent/Guardian Date

Appendix G

Consent for Use of PLTW Data for Dissertation Research

From:	Michelle Gough
To:	Vanessa Stratton
Subject:	consent for use of PLTW data for dissertation research
Date:	Thursday, August 31, 2017 4:25:55 PM

Dear Vanessa,

Please allow this email to serve as authorization to utilize the following PLTW data for your dissertation research:

- Data collected through student and teacher focus groups at the 2017 PLTW Summit event and throughout October and December 2017, for which specific consent has been obtained by you as the Researcher; and

- Data collected through PLTW Spring 2017 and PLTW Fall 2017 student and teacher surveys.

These data must utilized on PLTW equipment and pursuant to PLTW policies and procedures for handling data. They may only be reported in aggregate and may not individually identify any students, teachers, or schools.

Once you have completed your dissertation research project, these and all other PLTW data should only be pursuant to your position as Vice President of Programs at PLTW, unless and until another consent has been provided.

Best,

Michelle

Michelle Gough, J.D., Ph.D.
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