A Comparison of Cooperative Learning and Collaboration in High School Geometry Classes Including Geometry in Construction

Shelley Gates

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A COMPARISON OF COOPERATIVE LEARNING AND COLLABORATION IN HIGH SCHOOL GEOMETRY CLASSES INCLUDING GEOMETRY IN CONSTRUCTION

Shelley Gates

Educational Leadership Doctoral Program

Submitted in partial fulfillment of the requirements of Doctor of Education

In the Foster G. McGaw Graduate School

National College of Education

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A THREE-PART DISSERTATION:

A COMPARISON OF COOPERATIVE LEARNING AND COLLABORATION IN HIGH SCHOOL GEOMETRY CLASSES INCLUDING GEOMETRY IN CONSTRUCTION

PERCEPTIONS OF A TRADITIONAL HIGH SCHOOL BELL SCHEDULE IN THE 21ST CENTURY

ADVOCATING FOR THE ADOPTION OF A COMPREHENSIVE WORK BASED LEARNING SYSTEM

Shelley Gates

Educational Leadership Doctoral Program

Approved:

Angela Elkordy
Chair, Dissertation Committee

Elizabeth Minn
Member, Dissertation Committee

Christine Nelson
Dean’s Representative

Director, EDL Doctoral Program

Dean, National College of Education

Date Approved

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This document was created as one part of the three-part dissertation requirement of the National Louis University (NLU) Educational Leadership (EDL) Doctoral Program. The National Louis Educational Leadership EdD is a professional practice degree program (Shulman et al., 2006). For the dissertation requirement, doctoral candidates are required to plan, research, and implement three major projects, one each year, within their school or district with a focus on professional practice. The three projects are:

- Program Evaluation
- Change Leadership Plan
- Policy Advocacy Document

For the Program Evaluation candidates are required to identify and evaluate a program or practice within their school or district. The “program” can be a current initiative; a grant project; a common practice; or a movement. Focused on utilization, the evaluation can be formative, summative, or developmental (Patton, 2008). The candidate must demonstrate how the evaluation directly relates to student learning. My Program Evaluation is entitled, “A Comparison of Cooperative Learning and Collaboration in High School Geometry Classes Including Geometry in Construction.” I chose to evaluate an aspect of the Geometry in Construction program because it exemplifies what I believe to be “best practices” for student learning: hands-on, contextual, interdisciplinary, and team-oriented.

In the Change Leadership Plan candidates develop a plan that considers organizational possibilities for renewal. The plan for organizational change may be at the building or district level. It must be related to an area in need of improvement, and have a clear target in mind. The candidate must be able to identify noticeable and feasible differences that should exist as a result of the change plan (Wagner et al., 2006). My Change Leadership Plan is entitled, “Perceptions of a Traditional Bell Schedule in the 21st Century.” I selected this topic because what I believe works best for student engagement and learning (hands-on, contextual, interdisciplinary, and team-oriented) requires blocks of time that are not currently available to most teachers at my school which operates under a traditional 42-minute bell schedule.

In the Policy Advocacy Document candidates develop and advocate for a policy at the local, state or national level using reflective practice and research as a means for supporting and promoting reforms in education. Policy advocacy dissertations use critical theory to address moral and ethical issues of policy formation and administrative decision making (i.e., what ought to be). The purpose is to develop reflective, humane and social critics, moral leaders, and competent professionals, guided by a critical practical rational model (Browder, 1995). My Policy Advocacy Document is entitled, “Advocating for the Adoption of a Comprehensive Work-Based Learning System.” I chose this topic based on my belief that a primary goal of education is to prepare all young people for viable and fulfilling lives beyond high school. I chose to research and write about Work-Based Learning as it exemplifies what I believe to be “best practices” in education. Namely, Work-Based Learning nearly always includes hands-on, contextual, interdisciplinary, and team-oriented learning.

Works Cited
ABSTRACT

Currently offered at over 450 high schools in the United States, Geometry in Construction is an interdisciplinary course that provides students with the opportunity to learn Geometry content through the process of constructing a single-family home. Highly functioning cooperative groups are a critical element of the Geometry in Construction program. Cooperative learning is an effective instructional strategy that increases student achievement (Slavin, 2011) and also provides opportunities for students to develop collaboration and teamwork skills. Collaboration and teamwork are critical 21st century skills that are highly valued by employers and therefore worthy of consideration as foundational skills to be taught and assessed in US schools. This program evaluation explores the use of cooperative learning in Geometry classrooms, including Geometry in Construction, and its relationship to students’ development of the 21st century skill of collaboration. This study involved observations in Geometry classes to document the use of the instructional strategy of cooperative learning as well as a review of data collected via a retrospective pretest of Geometry students’ attitudes toward math and perceptions of their 21st century skills. While the classroom observations did not reveal significant differences in the quantity or quality of small group work in Geometry in Construction versus other Geometry classes, the data collected via the observation process can lead to thoughtful discussion and planning to increase the use of cooperative learning strategies. The results of the retrospective pretest showed a higher percentage of all students in Geometry (Geometry in Construction and in all other Geometry classes combined) indicating that they believed statements related to teamwork and collaboration were often or almost always true for them at the end of the school year than what they believed to be true for themselves before they took their current Geometry class. However, the researcher was encouraged that for the majority of
the statements related to teamwork and collaboration, the increase from pre to post was higher for *Geometry in Construction* students.
PREFACE: LESSONS LEARNED

I remember attending a workshop to learn about the Geometry in Construction program several years ago. As I listened to the founders (Scott Burke, Construction Teacher and Tom Moore, Geometry teacher) explain why and how they developed the program, I felt a sense of connection. Yes, we need to provide opportunities for students to learn math through real world applications. Yes, we need to help students learn construction skills. Yes, having a service application (building affordable housing) is a great way to increase student engagement. Yes, we need to break down the silos that separate Career and Technical Education from traditional academic areas like math. When the Mathematics Department Chair shared my enthusiasm for the program, I knew we had to try to make it happen at our high school. While challenging and complicated, the adoption and continuing implementation of the Geometry in Construction program has been successful in many ways. It has proven to be everything we hoped for and more.

Our successful implementation of the Geometry in Construction model has garnered interest from dozens of area high schools, leading us to schedule visitation days for teams of administrators and teachers to observe the program in action. Our visitors ask us technical questions about the cost of the program, the schedule, the teacher team, student recruitment, and how we build and move a house to a lot in our community every year. While I feel confident in how to answer all of these questions, I am always unsure about how to answer another frequently asked question: “How do you know it works?” This question usually leads to an explanation from our Mathematics Department Chair about Geometry grades and test scores, connections to standardized test results, and an assurance that Geometry in Construction students do as well as other students in their next math course, 2 Algebra. I usually add to this explanation by asking
our visitors to think beyond these traditional means of measuring educational program success to consider the other benefits of contextual teaching such as student engagement and the development of 21st century skills like collaboration and critical thinking skills.

This program evaluation developed out of a desire to increase my understanding of contextual teaching and learning in ways that go beyond traditional measures like test scores. The myriad ways that participation in a hands-on, interdisciplinary, contextual, and team-oriented high school course could impact students (as well as the scarcity of previous research regarding the impact of Geometry in Construction on student outcomes) made it difficult to develop specific, measurable research questions. I ultimately chose to focus on the use of cooperative learning in Geometry classrooms, including Geometry in Construction, based primarily on the program’s strong emphasis on cooperative grouping and team-building. Each stage of the research process -- formulating the research questions, reviewing previous research, completing focused classroom observations, and analyzing quantitative survey results – provided me with lessons regarding program evaluation. Perhaps most importantly, I have an increased awareness of the need to move beyond my subjective beliefs about educational initiatives and find ways to objectively demonstrate their worth. In addition, I understand the importance of viewing program evaluation as an on-going, long-term process that requires educators to continually revise research questions and data collection techniques, and stay up-to-date on the findings of other researchers in the field.

Although my findings were less conclusive than I had hoped, the program evaluation process has heightened my commitment to documenting successful ways to help all students learn and prepare to become successful adults in the 21st century.
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SECTION ONE: INTRODUCTION

Purpose

The primary purpose of this program evaluation was to examine the use of cooperative learning as an instructional strategy in Geometry classrooms and to increase understanding of whether and how participation in cooperative learning impacted Geometry students’ perceptions of their collaboration and team work skills. My interest in cooperative learning and its connection to collaboration and team work skills is based on my observations of the teaching and learning in an interdisciplinary course called *Geometry in Construction* which we have offered at our high school since 2013. *Geometry in Construction* is an intervention that was developed at Loveland High School in Loveland, Colorado, to enable students to learn Geometry content through the process of constructing a single-family home (Thompson R2J School District, 2009). The program was initially conceived in 2005 by a Geometry teacher, a Construction teacher, and a Career and Technical Education Department Chair who were searching for ways to help students identify the relevance of Geometry by infusing it into a Career and Technical Education course. Their goal was to develop a curriculum that would help all students see the relevance of mathematics through a real world model, which in this case, is the construction of a full-scale house. Based on input from business and industry representatives in their area, they focused on developing a curriculum that would provide students with strong math skills as well as employability skills such as teamwork, problem-solving, and communication (Burke & Moore, 2007). Upon implementation of the course in Colorado, on average, students participating in the *Geometry in Construction* program earned higher overall standardized Geometry test scores than all other geometry students combined in the district (Thompson R2J School District, 2009). The Colorado results indicated that teaching the math content in the context of constructing a house
provided students with additional motivation to learn the material, a better understanding of the math concepts, hands-on experience in a career field, and an increased capacity to work as part of a team (National Research Center for Career and Technical Education, 2011). As of 2018, the *Geometry in Construction* course was adopted by approximately 450 high schools around the country (NBC Nightly News, 2018).

Adoption of the *Geometry in Construction* program was initially proposed by the Career and Technical Education and Mathematics Departments at Willard Township High School (WTHS) in 2012 and first implemented in the 2013/2014 school year. The course was co-taught by a Mathematics teacher and a Construction teacher. Students enrolled in the double-period course earned two Geometry credits and two Construction credits for the full year course. The course was offered for either regular or honors credit which provided a unique opportunity for students to take a mixed-level Geometry course at WTHS (other Geometry courses at WTHS were *Geometry Honors*, *Geometry Regular*, or *Geometry with Support* which were not offered as mixed-level courses). Each year, the *Geometry in Construction* students built the basic structure of a 3-bedroom, 2.5 bath home in a parking lot near their classroom. Students gained hands-on construction experience in framing, roofing, and installation of windows, doors, and stairs. At the end of the school year, the home was transported to a lot in the community, completed by licensed contractors, and sold to a first-time home-buying family. The program was made possible by a partnership between the high school, city government, and a local affordable housing organization as well as by donations of materials and time from community business partners. The course consistently enrolled close to 100 students each year (3 sections). In the 2018-2019 school year, students were building a sixth single-family home which would eventually be purchased by a local family. Our program was highly rated by the founders of the
Geometry in Construction program who were particularly impressed by the program culture which emphasized cooperative grouping and team building techniques (Burke & Moore, 2016). Over the last six years, we received enthusiastic support from the WTHS administration and school board and maintained positive partnerships with local government, community organizations, and area businesses. The popularity and perceived success of the program led to the development and implementation of an additional interdisciplinary course at WTHS entitled Algebra in Entrepreneurship.

Along with this overall success, Geometry in Construction generated many questions (both within our school district and amongst other school districts who are considering implementing the program) regarding its benefits to students. Strong areas of interest for me were Geometry in Construction’s use of cooperative learning as an instructional strategy and its impact on the development of students’ 21st century skills, particularly collaboration. I believed that understanding the interconnection between the Geometry in Construction program’s use of cooperative learning strategies and student development of team-building or collaboration skills was important in light of the current emphasis on the need to prepare students to be successful in the 21st century as advocated by employers and educators (Partnership for 21st Century Learning, 2015; Symonds, Schwartz & Ferguson, 2011; Wagner, 2008). Like many other high schools, we were eager to find new ways to prepare students for the demands of the global knowledge economy. We recognized that too many of our students left high school without the knowledge and skills they needed to be successful in a world that demanded young people who could think critically, solve problems, collaborate with others, take initiative, and innovate (Wagner, 2008). Understanding the importance of transforming ourselves from the industrial sorting machine high school model of the 20th century into a new model of learning has required
us to consider ways to increase integrative, experiential learning that enables students to develop 21st century employability skills, including collaboration, grounded in rigorous academic and technical content (Stam, 2011).

To address the needs of the 21st century learner, a variety of instructional strategies and models have been developed, tested, and implemented around the country. These include but are not limited to project-based learning, contextual learning, career academies, interdisciplinary learning, and work-based learning. What they all have in common is a focus on helping students understand how to apply what they are learning in real-world contexts and an emphasis on the development of 21st century competencies (Brand, 2013; Symonds et al., 2011; Wagner, 2008), including collaboration and teamwork. *Geometry in Construction* is a unique blend of many aspects of these models, particularly interdisciplinary learning and contextual learning.

Like many high schools in the United States, WTHS has struggled with how to balance the need to implement teaching strategies that lead to ever higher levels of student achievement and at the same time, prepare students to be successful in the global economy. The dual purpose of collaboration in the classroom -- helping students improve their academic performance as well as develop necessary skills for the 21st century -- has been documented by researchers from around the world (Sulaiman & Shahrill, 2015; Capar & Tarim, 2013; Gasser, 2011) making it a *win-win* educational opportunity. Increasingly, high quality group work is valued as a way for students to understand academic concepts as well as a way for students to learn to reason and challenge others’ reasoning which are important workplace skills (Boaler, 2016).
Rationale and Goals

As Department Chair of Career and Technical Education, I co-led the development and implementation of the Geometry in Construction course at WTHS. I am a strong proponent of interdisciplinary courses and project-based learning (PBL) based on evidence that they can enhance student engagement; increase self-confidence and self-efficacy; promote the development of competencies such as teamwork, communication, creativity, problem-solving, and critical thinking; and expose students to a wide range of post-secondary options (Foote, Vermette, & Battaglia, 2014; Boss & Mergendoller, 2015; Stone, 2017). For me, one of the most compelling aspects of the Geometry in Construction model is the focus on collaboration and teamwork. Highly functioning cooperative groups are a critical element of the Geometry in Construction model. In fact, each lesson of the Geometry in Construction curriculum includes specific cooperative group activities (Burke & Moore, 2007). Every time the students (who are mostly 9th graders) are working on the construction site (approximately every other day), they are working in a group that has been given a specific task to complete. At the end of the class period, team members must decide together how to divide up the participation points and complete the Geometry in Construction Employability Card (Figure 1). This information is reviewed by the teachers and recorded as part of each student’s grade. My understanding and appreciation of the importance of cooperative groups as a part of the Geometry in Construction class has grown through many classroom observations on construction days over the past 5 years. With very few exceptions, I have observed students working efficiently and effectively in their groups without a great deal of oversight from the teachers. The emphasis on the importance of teams in the Geometry in Construction class led to my interest in learning more
about the instructional strategy of cooperative learning and how the use of cooperative learning as an instructional strategy affects the development of collaboration as a 21st century skill.

Figure 1: Geometry in Construction Employability Card

| DATE: ______________________________ | Individuals |
| Teacher: _______________ Period: ______ | Team Lead_______________ /13 |
| Table # ________ | 2) ________________ /13 |
| O – On Time and Prepared | 3) ________________ /13 |
| W – With Respect for yourself and Others | 4) ________________ /13 |
| N – Need to Excel in ALL you do | 5) ________________ /13 |
| I – Integrity | TOTAL POINTS: |
| T – Take Responsibility | 3 people = 31, 4 people = 41, 5 people = 51 |

What did you accomplish?

Because of my interest in understanding the extent to which students’ collaboration skills were positively impacted by their exposure to and participation in cooperative learning in Geometry classes, it was important to develop working definitions of cooperative learning as an instructional strategy and collaboration as a 21st century skill. Defining the instructional strategy of cooperative learning was complicated by the fact that the terminology associated with the various types of group learning is often unclear and overlapping (Davidson & Major, 2014). In
fact, cooperative learning fits into the larger category of instructional strategies called group learning which also includes collaborative learning and problem-based learning. (Davidson & Major, 2014). While all three of these small group learning approaches focus on active learning techniques to increase student engagement as well as the promotion of interdependence amongst group members, there are distinct differences. Because of the specific emphasis on cooperative learning activities in the Geometry in Construction curriculum, this program evaluation focused on the use of the group learning strategy of cooperative learning, broadly defined as a set of instructional methods in which a teacher creates group structure for students to work together on academic tasks (Davidson & Major, 2014; Johnson & Johnson, 2009; Slavin, 2011). Kagan and Kagan (2009) specify three key elements that must be present in cooperative learning: positive interdependence amongst group members, individual student accountability, and equal participation amongst group members. A goal of this program evaluation was to ascertain whether teachers in the Geometry in Construction program used more or different cooperative learning strategies than other Geometry teachers. As part of this goal, I intended to examine the interconnection between the amount of time students spent in cooperative learning and the quality of the classroom discussion.

Another goal of this program evaluation was to increase understanding of how enrollment in the Geometry in Construction program versus other Geometry courses impacted students’ perceptions of their collaboration and team work skills. The 21st century skill of collaboration is defined as the ability to work effectively and respectfully with others while exercising the flexibility necessary to accomplish a common goal (Partnership for 21st Learning, 2015). Based on my observations of students successfully collaborating to complete required tasks on the Geometry in Construction build site, I wanted to know whether Geometry in Construction
students’ perceptions of themselves as collaborators was different from the perceptions of students enrolled in other Geometry classes. For the purposes of this program evaluation, the terms collaboration and teamwork were used interchangeably and the skills are characterized by a student’s ability to consider the opinions of and work effectively with others.

The overarching goal of this program evaluation was to determine possible connections between the use of cooperative learning strategies in Geometry classes and students’ development of the 21st century skill of collaboration. Participating in cooperative learning in the classroom has been shown to assist students in the development of 21st century skills (Sulaiman & Shahrill, 2015; Capar & Tarim, 2013; Gasser, 2011); this program evaluation was an attempt to document whether and how this was occurring in Geometry classes at WTHS. Overall, I believed this examination could add to the larger discourse regarding the use of cooperative learning in Geometry classes; best practices in contextual, project-based, and interdisciplinary learning; and the impact of cooperative learning on the development of student collaboration skills.

**Research Questions**

The primary research question for this program evaluation was, “Are there differences in the use of cooperative learning in *Geometry in Construction* versus other Geometry classes at WTHS?” To answer this question, I conducted classroom observations in *Geometry in Construction* as well as other Geometry classes at WTHS. The secondary research question was, “Do students enrolled in *Geometry in Construction* perceive their attainment of 21st century skills (particularly those related to teamwork and collaboration) differently than students enrolled in other Geometry classes at WTHS?” To answer this question, I reviewed data from a
retrospective pre-test administered to all Geometry students at the end of the 2016-2017 school year. This survey was designed and administered by the district’s Research and Evaluation staff under the direction of the Assistant Superintendent for Curriculum and Instruction.
SECTION TWO: LITERATURE REVIEW

Introduction

This literature review focuses on the concept of collaboration as an important 21st century skill, the instructional strategy of cooperative learning, and the potential connection between the two. As summarized in this literature review, collaboration and teamwork are critical 21st century skills that are highly valued by employers and therefore worthy of consideration as foundational skills to be taught and assessed in US schools. At the same time, cooperative learning is an effective instructional strategy that not only increases student achievement (Slavin, 2011) but provides opportunities for students to develop collaboration and teamwork skills.

In this section, I examine how the skill of collaboration fits into the overall 21st century skill movement. I also review the body of research pertaining to the instructional strategy of cooperative learning and its potential for promoting equitable learning outcomes. Because my research questions are specific to the use of cooperative learning in Geometry classes, a review of the use of various grouping strategies in the teaching of Mathematics is included. Finally, I discuss the complexity of teaching and assessing 21st century skills.

Collaboration as a 21st Century Skill

The roots of the current 21st century skill movement can be found in the work of John Dewey who proposed that education should provide students with opportunities to interact with an ever changing world, as well as in Benjamin Bloom’s ubiquitous taxonomy which promotes complex thinking (Larson & Miller, 2011). However, as we entered the second decade of the 21st century, policymakers and researchers voiced an increasingly urgent concern about the
large numbers of young people who lack the skills, knowledge, experience and aptitudes necessary for success in an increasingly complex world (Symonds et al., 2011; Wagner, 2008; CCSSO, 2014; Brand, 2013). The US economy requires a better educated workforce than in the past, and jobs in this new economy require more complex knowledge and skills. In nearly every sector of today’s economy, workers must be able to find and analyze information from multiple sources and then use this information to create new ideas and make decisions (Silva, 2009). While the ability to communicate and navigate relationship challenges in the workplace are often ranked as the most desirable skills in employer surveys, even college graduates often lack these basic 21st century skills (Stone, 2017). In short, many young adults in the US lack the skills needed to attain and keep jobs that pay even a middle class wage (Symonds, et al., 2011).

In his book, “The Global Achievement Gap: Why Even Our Best Schools Don’t Teach The New Survival Skills Our Children Need and What We Can Do About It,” Tony Wagner (2008) provides detailed descriptions of seven survival skills that he believes all young people need to be successful in the 21st century: critical thinking and problem solving; collaboration across networks and leading by influence; agility and adaptability; initiative and entrepreneurialism; effective oral and written communication; accessing and analyzing information; and curiosity and imagination (Wagner, 2008). The Partnership for 21st Century Learning, P21 (formerly the Partnership for 21st Century Skills), was founded in 2002 as a coalition to bring attention to the importance of 21st century readiness in the US K-12 education system. Their P21 Framework echoes many of Wagner’s survival skills and adds others such as mastery of key academic subjects (English, world languages, arts, mathematics, economics, science, geography, history, government/civics); global awareness; financial and business literacy; media literacy; social and cross-cultural skills; productivity and accountability; and
leadership and responsibility (Partnership for 21st Century Learning, 2015). Recent efforts by organizations like Achieve and the Career Readiness Partner Council have focused on developing career-focused readiness indicators. As one could expect, these indicators include proficiency in core academic subjects as well as a level of technical-skill proficiency aligned to a particular career pathway. However, they also encompass a number of employability skills and dispositions including goal setting and planning, ethical decision making, goal setting, team-building, and communication skills (Kreamer, O’Hara, & Curl, 2014). While there are multiple ways to view the definitions, scope, and content of 21st century skills, students’ ability to apply these skills in authentic contexts is increasingly emphasized (Larson & Miller, 2011).

The 21st century skill of collaboration is defined as the ability to work effectively and respectfully with others while exercising the flexibility necessary to accomplish a common goal (Partnership for 21st Learning, 2015). As a life skill, collaboration requires individuals to accept responsibility for their own actions while, at the same time, learning about and respecting the abilities and contributions of their peers. Key features of collaboration include respecting individual group members’ abilities and contributions, and sharing responsibility and authority over group decisions (Laal & Ghodsi, 2011). Increasingly, innovation and the solving of multifaceted problems are the result of team efforts that require team members to not only navigate cultural differences but use a variety of technological tools effectively (Boss, Larmer, & Mergendoller, 2015). The ability to collaborate is seen as critical by most American companies based on the fact that many of today’s problems are too big and complex for any one person to solve alone (Johnson, E. B., 2002; Johnson, L., 2017).

The 21st century skills of communication and collaboration are often discussed in tandem as it is difficult to learn or apply either skill without the other. For example, communication
skills are necessary for students to collaboratively solve problems or engage with others in inquiry-based activities (Larson & Miller, 2011; Johnson, L., 2017). In fact, communication and collaboration are seen as gateway skills to rest of the 21st century skills as they lead to what can be considered the more complicated, sophisticated skills of critical thinking, problem-solving, stress management, and risk-taking (Jacobson-Lundeberg, 2013).

**Collaboration and Cooperative Learning as Instructional Strategies**

While collaboration is a desirable 21st century skill, it is also considered to be an effective instructional strategy. Collaborative learning is broadly defined as “any instructional method in which students work together in small groups toward a common goal” (Prince, 2004, p. 223) and encompasses all forms of group or team-based instructional techniques, including cooperative learning (Prince, 2004). In fact, collaborative learning, cooperative learning, problem-based, and project-based learning are forms of group learning that fall under the larger umbrella of active learning (Davidson & Major, 2014). All of these active learning techniques are designed to increase student engagement in the learning process by requiring students to do meaningful learning activities and think about what they are doing (Prince, 2004). Active learning is seen as contrasting with traditional instructional methods such as lecturing.

Interest in small-group learning techniques, particularly cooperative learning, has been growing at all levels of education over the past several decades. This interest is based on compelling evidence that students working in small groups outperform those working individually in key areas such as knowledge development, thinking skills, social skills, and course satisfaction (Davidson & Major, 2014). According to David W. and Roger T. Johnson, seminal researchers on the topic of social interdependence theory and cooperative learning, “few
instructional strategies have been more successfully implemented in the past 60 years than cooperative learning” (Johnson & Johnson, 2009, p. 365). At a basic level, cooperative learning refers to a set of instructional methods in which a teacher creates group structure for students to work together on academic tasks (Davidson & Major, 2014; Johnson & Johnson, 2009; Slavin, 2011). Helping students more effectively learn academic content has been a major goal of cooperative learning since the term was conceived in the late 1960s. At that early stage, a mathematics professor developed what was referred to as a *small group discovery method* which provided the opportunity for students enrolled in a calculus course to work in small groups to discuss mathematical ideas, develop ways to solve problems, and discover new ideas and techniques (Davidson & Major, 2014). Today, cooperative learning encompasses a variety of techniques or strategies including Teams-Games-Tournament, Student Teams Achievement Divisions, group investigation, academic controversy, jigsaw, Team Assisted Individualization, complex instruction, the structural approach, Cooperative Integrated Reading and Composition Program and many more (Johnson & Johnson, 2009). The five defining elements of cooperative learning are summarized below:

- *Positive interdependence* (a sense of sink or swim together).
- *Face-to-face promotive interaction* (helping each other learn, applauding success and efforts).
- *Individual and group accountability* (each of us has to contribute to the group achieving its goals).
- *Interpersonal and small group skills* (communication, trust, leadership, decision making and conflict resolution).
- *Group processing* (reflecting on how well the team is functioning and how to function even better)

David and Roger Johnson, along with their colleague Edythe Johnson Holubec (2008), describe three different types of cooperative learning -- formal, informal, and base groups -- to provide additional clarification regarding the elements required for successful implementation. Formal cooperative learning consists of small groups of students working together over a specified period of time (one class period to several weeks) to accomplish a shared learning goal and complete a specific task or assignment. Key elements of formal cooperative learning include pre-instructional decisions by the teacher (establishing learning objectives, determining the size the groups, the method of assigning students to groups, and roles students will be assigned within their group), a clearly defined assignment and assessment criteria which are shared with the students ahead of time, and monitoring of groups to provide assistance with completing the task and/or increase students’ group skills. Informal cooperative learning consists of having students work together to meet a learning objective or complete a task in temporary, ad hoc groups that last from a few minutes to one class period. Informal cooperative learning includes having a small groups of students quickly respond to a limited number of questions about the day’s topic or turn-to-your-partner discussions interspersed throughout a lesson. Informal cooperative learning can be used to help focus students’ attention on the material to be learned, clarify expectations for tasks, ensure that students are actively processing the material being taught, or provide time for closure. Cooperative base groups are long-term heterogeneous groups (e.g., for a semester or school year) created to provide students with support and encouragement (Johnson, Johnson, & Holubec, 2008; Marzano, Pickering, & Pollock, 2001). The more structured forms of cooperative learning that have proven to be most effective are not used as often as more informal forms (Slavin, 2011). This is problematic because informal cooperative learning does not incorporate the development of group goals and
a level of individual accountability which are essential for optimal learning (Slavin, 2011). Compounding this problem is the fact that there remains a common misconception in US schools that cooperative learning and group work are the same instructional strategy (White & Braddy, 2017). Group work can be defined as giving a group of students a task without providing explicit structuring or roles for the group members (Kagan & Kagan, 2009). The goal for the group work is for the students to complete a task together. This is in contrast to cooperative learning where the teacher provides students with a structure to ensure equal and productive work by all of the group members. Researchers and experts have identified four areas that must be addressed by teachers implementing effective cooperative learning: establishing positive group norms, structuring learning activities in ways that support learning and understanding, modeling appropriate behaviors, and monitoring students as they are working together in groups (Webb, Farivar, & Mastergeorge, 2001; Johnson, Johnson, & Holubec, 2008; Kagan, 2009; Marzano, Pickering, & Pollock, 2001). Ideally, student roles are clearly defined and the task is designed to elicit deeper thinking and engagement of all members, as well as accountability for each member (White & Braddy, 2017). While having the appropriate structures in place is important to the success of cooperative learning, teachers also need to take the time to teach students the skills that are necessary for being an effective team member (Webb, Farivar, & Mastergeorge, 2002). This is because students often have a difficult time figuring out how to work together, manage time, and maintain motivation in the face of confusion or setbacks (Barron & Darling-Hammond, 2007). Talking activities that lack depth, such as a brief turn-and-talk or pair-share with a neighbor, are not sufficient to help students build the necessary skills and stamina to engage in meaningful academic dialogue (Hammond, 2015). The skills students need help to develop include active listening, communicating ideas
and opinions in a clear and persuasive manner, encouraging the participation of other teammates, and completing tasks (Slavin, 2014).

According to Robert E. Slavin (2014), cooperative learning has a place in every lesson but should not be the entire lesson. It should be applied consistently (at least once per week) and in an organized fashion but not overused (Marzano, Pickering, & Pollock, 2001). To optimize cooperative learning, it should be used along with direct teacher instruction, media- or computer-based activities, and individual work. One optimal time to use group work in a traditional lesson cycle is after the teacher has provided instruction on a topic and before learning is assessed. This is because practicing on an individual, isolated basis is boring and ineffective for most students, particularly if they are struggling learners (Slavin, 2014).

Slavin (2011) lamented that even with 30 years of foundational research supporting its value as an instructional strategy, along with the added benefit that it is relatively inexpensive to implement, cooperative learning has not been widely adopted by many schools. This may be because the maximization of the potential of cooperative learning as a powerful instructional strategy depends on the provision of robust professional development for teachers that focuses on the forms of cooperative learning that are most likely to make a difference (Slavin, 2011).

**Impact of Cooperative Learning on Student Achievement and Potential for Promoting Equitable Learning Outcomes**

Cooperative learning methods have been extensively researched and are known to substantially improve student achievement in many subjects and grade levels (Slavin, 2011). Research has proven that all forms of small-group work enhance active engagement in learning, stimulate cognitive activities, promote student-to-student interaction, and result in increased student achievement, motivation, knowledge retention, the development of critical
thinking skills and creativity, and positive feelings toward peers (Davidson & Major, 2014; Ginsburg-Block et al., 2006; Johnson & Johnson, 2009; Kagan, S., 2010; Rohrbeck et al., 2003; Tran, 2014). A number of experimental studies have found that students working in groups outperform students working on their own on academic tasks (Barron & Darling-Hammond, 2007). Overall, organizing students in cooperative learning groups has a powerful and positive effect on learning, regardless of whether groups compete with one another (Marzano, Pickering, & Pollock, 2001). Researchers have pinpointed a variety of social processes embedded in collaborative instructional practices that lead to these positive outcomes for students including the opportunity to share original insights, resolve differing perspectives via argument, explain one’s thinking to others, provide critique of others’ ideas or products, observe others’ strategies for problem-solving, and listen to others’ explanations (Barron & Darling-Hammond, 2007).

In terms of addressing the needs of students with academic challenges, cooperative learning has been considered a viable alternative to ability grouping and tracking and as a potential strategy for promoting achievement in academically and linguistically heterogeneous classrooms (Cohen, et al., 1999; Kagan, M., 2007). Developing and using teaching strategies that emphasize cooperation and collaboration can be seen as supportive of the cultural value of collectivism which is shared by immigrant families (as well as American Indians, Alaska Natives, Pacific Islanders, and African Americans). A large body of research supports the idea that two broad cultural value systems, individualism and collectivism, shape people’s perspectives on life (Rothstein-Fisch & Trumbull, 2008). Schools in the US overwhelmingly reflect the values of the dominant White culture brought to North America by Western Europeans. These values reflect an emphasis on teaching children to be independent and achieve success on an individual level. In contrast, families embracing a collectivist perspective teach
young people the skills and attributes necessary to be an acceptable group member (Rothstein-Fisch & Trumbull, 2008). Teachers who have an understanding of both collectivistic and individualistic values can develop group-based activities to improve students’ skills in a wide range of academic areas (Rothstein-Fisch & Trumbull, 2008).

A potential pitfall to successful use of cooperative learning in a heterogeneous classroom includes the issue of exclusion of certain students from full participation. This includes students who are academically low achieving or social isolates (Cohen, et al., 1999). To avoid this problem, teachers who are implementing any form of cooperative learning or group work must employ strategies to ensure that all group members are active and influential participants. Using open-ended and/or inherently uncertain tasks (which increases the need for interaction between all students in a group) and multiple-ability tasks (which provides opportunities for students with a variety of abilities to demonstrate mastery) are ways to level the playing field within the group and encourage participation of all group members (Cohen, et al., 1999).

Collaborative Learning in a Mathematics Classroom

If, in fact, a key aspect of the teaching of mathematics is the active engagement of students in discussion and collaboration (Boaler, 2016; Zakaria, 2010), then it makes sense that cooperative learning is often cited as a recommended instructional strategy for improving mathematics education (Boaler, 2016; Esmonde, 2009; Shafer, 2016). Cooperative learning in a math classroom provides opportunities for students to explain and hear other students’ explanation of concepts which increases understanding. It provides the opportunity for students to “discuss, solve problems, create solutions, provide ideas and help each other” (Zakaria, 2010, p. 274). In her study of mathematics education at Railside High School in California, Jo Boaler
described the teachers’ cooperative learning approach as “communicative” (Boaler, 2008, p. 59) based in part on students regularly explaining their work to each other. Following the tenets of Complex Instruction, the Railside teachers focused on group dynamics and emphasized the importance of respecting the contributions of all group members regardless of their previous level of attainment in mathematics or their status with other students (Boaler, 2008). As is the case in other subject areas, this level of thoughtful implementation by the math teacher is required in order to prevent, for example, students learning incorrect mathematical strategies from each other or the perpetuation of students’ beliefs about who is good or bad at math (Boaler, 2008; Esmonde, 2009).

Another important benefit of implementation of cooperative learning strategies in a math classroom is increased student engagement and more positive attitudes towards mathematics (Boaler, 2016; Zakaria, 2010). When students are working in groups, they develop interdependence which leads to increased confidence in their mathematics capabilities. The social aspect of group work, along with the opportunities for active learning, lead to more positive attitudes about the subject area (Zakaria, 2010).

**Challenges to Teaching and Measuring Collaboration and Other 21st Century Skills**

Although the overall value of collaboration as an instructional strategy has been widely acknowledged, it is not without its risks. Effective cooperative learning can be difficult for teachers to implement and requires simultaneous changes in instruction, curriculum, and assessment practices. When students work in small groups, they can “exchange ignorance, carry unequal burdens, behave inefficiently, and argue” (Johnson, E. B., 2002, p. 89). In fact, studies have found that despite the extensive research that supports its use as a valuable instructional
strategy, most teachers do not use it regularly (Slavin, 2014) based in part on a perception that, too often, the learning part of cooperative learning is left out. According to Drs. Barron and Darling-Hammond (2007), teachers face major challenges when attempting to bring cooperative learning into their classrooms including the need to develop the norms and structures for group work, developing the appropriate tasks that support productive group work, and developing discipline-specific cooperative learning strategies that support deep learning of the content. Johnson and Johnson (2009) are proponents of finding ways to operationalize the educator’s role in the implementation of cooperative learning since many teachers do not have the benefit of watching a master teacher use cooperative learning strategies effectively.

While the techniques for effective implementation of cooperative learning in the classroom are well defined (if not always practiced), educators are still debating how best to teach and measure the broad range of 21st century skills (including collaboration). Instructional strategies for teaching skills such as collaboration, creativity and innovation are not as developed as techniques for teaching traditional academic content. Rotherham and Willingham (2009) point out that many 21st century skills proponents believe that providing students the opportunities to experience one or more of these skills will translate into actually learning the skills. For example, students working in groups will automatically develop collaboration skills. They refute this idea by suggesting that without structured practice and feedback, students will not have the opportunity to learn from their experiences and make improvements. The fact that teaching 21st century skills is currently closely aligned with student-centered teaching methods such as project-based learning (Boss et al., 2013; Rotherham & Willingham, 2009; Silva, 2009) provides a major challenge to widespread implementation since the majority of instructional time in US classrooms continues to be composed of the non-student-centered methods of seat-work

The difficulty of implementation of teaching strategies that promote 21st century skill development is matched by the complexity of measuring students’ attainment of these skills. The importance of measuring non-cognitive skills (including many 21st century skills) is captured by Martin R. West:

A growing body of evidence confirms that student skills not directly captured by tests of academic achievement and ability predict a broad range of academic and life outcomes...both intra-personal skills (such as the ability to regulate one’s behavior and persevere toward goals) and inter-personal skills (such as the ability to collaborate with others) are key complements to academic achievement in determining students’ success. (West, 2016, p. 2).

A major barrier to measuring students’ attainment of 21st century skills is the fact that high-stakes, standardized tests do not assess these competencies (Dede, 2009). However, new models of assessment that measure both traditional academic content knowledge and 21st century skills are being developed and implemented. Examples include the College Work Readiness Assessment which was designed to measure students’ critical thinking skills (Silva, 2009); the Programme for International Student Assessment which seeks to measure young people’s ability to apply their knowledge and skills to real-life challenges (Dede, 2009); Great Britain’s Key Stage ICT Literacy Assessment which measures students’ ability to solve complex problems using their research, communication, information management, and presentation skills (Dede, 2009); and Project Lead the Way’s End of Course Assessment which, beginning in 2019, will measure both course specific (Engineering, Biomedical Science, or Computer Science)
knowledge and transportable skills including collaboration, communication, creativity, critical thinking, ethical reasoning, and problem solving (Project Lead the Way, 2018).

In summary, this literature review provides a strong case for US high schools to continue to develop ways to teach and assess the important 21st century skills of collaboration and teamwork. Because the literature strongly supports cooperative learning as a powerful instructional strategy in mathematics as well as other content areas, high school educators would be wise to embrace its capacity to not only increase student achievement but to help students become strong collaborators.
SECTION THREE: METHODOLOGY

Before describing the research methodology for my program evaluation, it is important to provide background information about our district’s past efforts to evaluate the *Geometry in Construction* program. During the 2014/2015 school year, the WTHS Assistant Superintendent for Curriculum and Instruction formed a small working group to discuss possible ways to evaluate the *Geometry in Construction* and *Algebra in Entrepreneurship* programs. The working group consisted of the Assistant Superintendent for Curriculum Instruction, two staff members from the Research and Evaluation Department, the Mathematics Department Chair, and myself. The working group made a decision to conduct a comprehensive evaluation of both programs during the 2015-2016 school year (Figure 2).

Figure 2 -- WTHS Geometry in Construction and Algebra in Entrepreneurship Evaluation Plan 2015-2016 School Year (omitted for confidentiality, 2015).

<table>
<thead>
<tr>
<th>Evaluation Question</th>
<th>Data</th>
<th>Data Source</th>
<th>Method of Analysis</th>
<th>Cohort Analyzed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students: What are characteristics of the students taking the course? How do the characteristics of students taking the course compare to those of students taking other 1 Algebra/Geometry courses?</td>
<td>Gender, race/ethnicity; standardized math assessment scores</td>
<td>eSchool</td>
<td>Frequencies; chi-squares</td>
<td>2015-2016</td>
</tr>
<tr>
<td>Course Grades: What are students’ course grades? How do students’ course grades compare to those of students taking other 1 Algebra/Geometry courses?</td>
<td>Final exam grade; course grade</td>
<td>eSchool</td>
<td>Frequencies; chi-squares</td>
<td>2015-2016</td>
</tr>
<tr>
<td>Experiences in Current Math Course: What are students’ experiences in their current math course? How has this changed during the school year? How do students’ experiences compare to those students taking other 1 Algebra/Geometry courses?</td>
<td>Relevance; sense of belonging; confidence; stress</td>
<td>Student Survey</td>
<td>Student longitudinal analysis over year; students matched across other 1 Algebra/Geometry courses</td>
<td>2015-2016</td>
</tr>
<tr>
<td>Attitudes Toward Math and Learning Math: What are students’ attitudes toward math and learning math? How have these attitudes changed during the school year? How do students’ attitudes compare to those of students taking other 1 Algebra/Geometry courses?</td>
<td>Anxiety; aspirations; interest; self-efficacy; value of math</td>
<td>Student Survey</td>
<td>Student longitudinal analysis over year; students matched across other 1 Algebra/Geometry courses</td>
<td>2015-2016</td>
</tr>
<tr>
<td>21st Century Skills</td>
<td>How well do students learn 21st century skills? How have these skills changed during the school year? How does this compare to those students taking other 1 Algebra/Geometry courses?</td>
<td>Teamwork; creativity; problem solving; communication; risk taking</td>
<td>Student Survey</td>
<td>Students matched across other 1 Algebra/Geometry courses; frequencies; chi-squares</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>----------------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Mathematics Skills</td>
<td>How well do students learn 1 Algebra/Geometry skills? How does this compare to those students taking similar 1 Algebra/Geometry courses?</td>
<td>Gender; race/ethnicity; standardized math scores</td>
<td>STAR Math Assessment 5/16/16</td>
<td>Students matched across other 1 Algebra/Geometry courses; comparison of means</td>
</tr>
<tr>
<td>Growth in Mathematics</td>
<td>Do students show significant growth in their Algebra/Geometry skills? How does students’ growth compare to that of students taking other 1 Algebra/Geometry courses?</td>
<td>Gender; race/ethnicity; standardized math scores</td>
<td>STAR Math Assessment student growth percentile - 10/12/15 and 05/16/15</td>
<td>Student longitudinal analysis over year; students matched across other 1 Algebra/Geometry courses</td>
</tr>
<tr>
<td>Future Mathematics Courses</td>
<td>How successful are students in future math courses? How does students’ success compare to that of students taking other 1 Algebra/Geometry courses?</td>
<td>Gender; race/ethnicity; math course level; math course grades</td>
<td>eSchool</td>
<td>Students matched across other Geometry courses</td>
</tr>
</tbody>
</table>

The overall results of this ambitious research project were inconclusive and beyond the scope of this program evaluation. However, the process and outcomes of our working group provided me with a valuable lesson regarding the importance of identifying specific intended uses from the beginning of an evaluation process (Patton, 2008). In hindsight, it is clear to me that each person in the working group had their own priorities for the evaluation plan and rather than choosing one priority over the other, we chose to keep all of the priorities which resulted in an unwieldy and unrealistic evaluation plan. This first attempt to evaluate many aspects of the impact of the Geometry in Construction program allowed us to learn from our experience and then revise and narrow our focus for the following school year. For example, a major shortcoming of the 2015-2016 evaluation was the use of a pre- and post- student survey to determine changes in students’ experiences in their current math course, attitudes toward math and learning math, 21st century skills, and mathematics skills. The pre-survey was administered in all Geometry classes (including Geometry in Construction) in the fall of 2015 and the post-survey was administered in the same classes in the spring of 2016. Because some Geometry
teachers neglected to have their students complete the post-survey, the sample size for the post-survey administered in the spring was too small for the results to be valid. Staff from our Research and Evaluation department determined that our best course of action for the survey in the 2016-2017 school year would be to use a retrospective pretest which would be administered in the spring.

**Research Design Overview**

The goal of this research was to study the use of cooperative learning strategies in Geometry classes (including *Geometry in Construction*) and gain a better understanding of Geometry students’ perception of the attainment of the 21st century skills of teamwork and collaboration. I used a mixed methods design which included qualitative data derived from observations of Geometry classes and quantitative survey results that provided information regarding students’ perceptions of their 21st century skills. The mixed methods design allowed me to take advantage of the survey data that was already being collected by our Research and Evaluation staff to explore possible connections between cooperative learning in the classroom and students’ development of collaboration skills. In addition, combining methodologies helped me reduce my personal bias as a researcher (Patton, 2008).

The observations were completed in a range of Geometry classes (including *Geometry in Construction*, Geometry Regular, Geometry Honors, and Geometry Support classes co-taught by a Geometry teacher and a Special Education teacher) conducted during February, 2017. My research also included a review of the data from a retrospective pretest administered to all Geometry students (including those enrolled in Geometry in Construction) at the end of the 2016-2017 school year (Appendix A). The retrospective pretest was designed and administered by the WTHS Research and Evaluation Department.
Participants

The key participants in the observation portion of this program evaluation were Geometry teachers who agreed to participate. In an email to all Geometry teachers, the Mathematics Department Chair provided context for their participation by reminding them about the work WTHS was doing to explore how interdisciplinary courses (such as Geometry in Construction and Algebra in Entrepreneurship) impacted students’ attitudes and motivation regarding mathematics as well as their perceptions of their attainment of 21st-century skills such as teamwork and problem-solving ability. He also reminded them that one aspect of the exploration was the student survey that was administered the previous year in Geometry and Algebra courses. He informed them that as part of my doctoral research, I was requesting their permission to observe one or more of their Geometry class periods to document student engagement, peer interactions, and higher-order thinking. A total of 3 individual teachers (2 teachers of Geometry Honors and 1 teacher of Geometry Regular) and 2 teams of teachers (the co-teaching team of Geometry in Construction and a co-teaching team of Geometry with Support) agreed to participate. Once teachers expressed a willingness to be observed, I informed them that participation in this study was voluntary, encouraged them to ask any clarifying questions beforehand, and collected signed consent forms. The classroom observations were scheduled based on the preferences of each teacher or teacher team. Participants were notified that they were free to withdraw at any time and without giving a reason, and without consequence for doing so. I also made sure to communicate that participating and/or withdrawing from the study would not affect the relationship they had with me as the researcher or with the Mathematics Department Chair.
Participants in the retrospective pretest of students’ attitudes toward math and perceptions of their 21st century skills were all students taking Geometry including those enrolled in *Geometry in Construction*, Geometry with Support, Geometry Regular, and Geometry Honors at WTHS during the 2016-2017 school year. A total of 692 students completed the retrospective pretest. The retrospective pretest survey was designed to assess Geometry students’ attitudes toward math and their perceptions of their 21st century skills (Appendix A). The decision to use a retrospective pretest was based on prior difficulties with administration of a pre- and post-test during the 2015-2016 school year. Based on increasing demands for documenting a wide range of program outcomes, the retrospective pretest design has gained prominence based on simplicity and convenience and evidence that it is a valid method for measuring self-reported change (Klatt & Taylor-Powell, 2005; Pratt, McGuigan, & Katzev, 2000). Despite the fact that retrospective pretests have been found to be susceptible to biases both in self-appraisal and recall, they can be considered a useful program evaluation method in many situations (Klatt & Taylor-Powell, 2005). The Research and Evaluation staff determined that the retrospective pretest was the best alternative for the purposes of generating data regarding geometry students’ attitudes about math and their beliefs about their use of 21st century skills.

**Data Gathering Techniques**

To determine the extent to which there were differences in the use of cooperative learning strategies in *Geometry in Construction* versus other Geometry classes at WTHS, I completed classroom observations of nine different Geometry class periods including two periods of *Geometry in Construction*, two periods of Geometry with Support, four periods of Geometry Honors, and one period of Geometry Regular. At the beginning of each class period, I made a quick drawing of the classroom layout and, if the classroom was set up for group work, I
numbered each group and provided a notation about where students were seated within each small group. During each observation, I took on-going notes in a google sheet template designed for classroom observations. The google sheet provided space for literal notes and records the time for each entry. At the beginning of each entry, I used a code to indicate whether the instruction or classroom activity that I was recording was whole class instruction (WC), small group instruction (SG), peer sharing (P), or individual work (I).

To gain a greater understanding of the extent to which students enrolled in *Geometry in Construction* perceive their attainment of 21st century skills (particularly those related to teamwork and collaboration) differently than students enrolled in other Geometry classes at WTHS, I reviewed results of a retrospective pretest administered by the WTHS Research and Evaluation staff (Appendix A).

**Data Analysis Techniques**

To analyze of the use of cooperative learning in the Geometry classes I observed, I designed a Geometry Classroom Observation Tool (Appendix B), based in part on the Classroom Assessment Scoring System (CLASS) developed by Robert Pianta, Bridget Hamre, and Susan Mintz (2012) which emphasizes the importance of having an observer watch and code nearly all activities in the classroom. I used the tool to organize the information that I gathered via notetaking in the google sheet template and to document instances of student engagement as well as the amount of time students spent working in small groups, and to analyze student-to-student interactions within small groups. Based on my interest in understanding the extent to which cooperative learning increases student engagement and leads to higher-order thinking in the classroom, I used the observation tool to tally the number of instances of students asking higher-
order questions, and instances of students analyzing and interpreting data/information/approaches, instances of students constructing alternative solutions/predicting/hypothesizing/brainstorming, and instances of students developing arguments/providing explanations. I completed one Geometry Observation Tool worksheet for each of the nine classes I observed.

To increase my understanding of Geometry students’ perceptions regarding their use of 21st century skills (particularly collaboration and teamwork) in their current math class, I reviewed the results of the retrospective pretest completed by the WTHS Research and Evaluation department (Appendix A). Specifically, I reviewed student responses to three statements about their current math class: My teacher(s) give me the opportunity to lead groups, My teacher(s) give me time to work with other students, and My teacher(s) encourage me to consider the opinions of others. I also analyzed data from the student responses to 4 (out of a total of 11) of the 21st Century Skills retrospective pretest statements: I lead others to accomplish a goal, Others can count on me to accomplish a goal, I listen to what others say before acting, I think about how others see things.
SECTION FOUR: FINDINGS AND INTERPRETATION

The primary focus for this program evaluation was to determine whether there were differences in the use and impact of cooperative learning in Geometry in Construction classes versus other Geometry classes at WTHS and if so, document the differences. Based on my classroom observations of a variety of Geometry classes at WTHS (Geometry in Construction, Geometry with Support, Geometry Regular, and Geometry Honors), I found that the form of cooperative learning used in most of the classes, including Geometry in Construction, can be described as group work rather than cooperative learning (Kagan & Kagan, 2009). In two of the classes, (Geometry with Support), no form of cooperative learning or group work was used. In the 7 class sessions where some form of group work was observed, groups of 3 or 4 students were seated in a square or circle facing each other which appeared to facilitate communication among group members. In both of the Geometry with Support classes, the students were seated in rows facing the front of the classroom. In the 7 classes where group work was observed, teachers gave brief cues to students (Table 1) to discuss or talk with their group or team about a geometry problem without providing explicit structuring or roles for the group members. For example, in Geometry in Construction (class 1), the teacher stated, “In your teams, you have three minutes to do this opener.” However, in the other Geometry in Construction class that I observed (class 2), the teacher did not use the term team but did suggest that students should talk to their neighbors at one point in the class. All of the teachers in the Geometry Honors classes that I observed used the term group when directing students to discuss or talk to each other. The students in the Geometry Regular class that I observed were directed to introduce themselves to their group and to help others on their team. The use of these terms in these classes may indicate prior instruction to students regarding how best to work in their small groups or teams such as
clearly defined student roles and some form of accountability for each team member’s participation (White & Braddy, 2017). However, I did not observe any dialogue among students in small groups in any of the classes that pertained to student roles or accountability for team member participation or contribution to the conversation.

Table 1: Instances of teacher directions or feedback to students regarding small group work

<table>
<thead>
<tr>
<th>CLASS</th>
<th>SEATING ARRANGEMENT</th>
<th>TEACHER DIRECTIONS OR FEEDBACK TO STUDENTS REGARDING SMALL GROUP OR TEAM WORK</th>
</tr>
</thead>
</table>
| Geometry in Construction (class 1) | Students in groups of 3 or 4 | “In your teams, you have three minutes to do this opener.”  
“Did your team agree with you?”  
In reference to a quiz students are taking: “This is by yourselves.” |
| Geometry in Construction (class 2) | Students in groups of 3 or 4 | “We are asking you to work individually right now.”  
“The only conversation I should hear is you talking to me or Mr. K...no neighbor conversations right now.”  
“You can talk to your neighbors now.” |
| Geometry Honors (class 1) | Students in groups of 3 or 4 | “So your instructions are when the timer starts, completely on your own, mark anything on here that you can identify…”  
“At this point, work with your group.”  
“All right, let’s regroup...take 5 seconds to finish the conversation you are having.”  
“Get yourselves ready, we are about to start talking.”  
“Discuss what makes an arc minor versus major.”  
“Now take a minute and chew on this and see if you can complete the problem.” |
| Geometry Honors (class 2) | Students in groups of 3 or 4 | “Here is what we are going to do...I am putting a timer on the screen...you have two minutes...ready go on your own…”  
“Let’s take a few minutes in your small group and discuss.”  
“We are sharing out...be prepared to share what your group talked about.”  
“In your group, talk about why it is called a major arc.”  
“So just 5 seconds in your group...what does this mean?”  
“OK, let’s share out.”  
“Talk in your groups.” |
| Geometry Honors (class 3) | Students in groups of 3 or 4 | “I need a volunteer from your group.” |
| Geometry Honors (class 4) | Students in groups of 3 or 4 | “30 seconds discuss with your group why this has to be a right angle.”  
“OK come back now (to whole group).”  
“Let’s come back together.”  
“Can we come back together please.” |
| Geometry Regular (class 1) | Students in groups of 3 or 4 | “OK just for me...Can you rotate your groups? Can you introduce yourselves to your group please?”  
“If you finish early, you can help others on your team. If your team doesn’t need help, you can go around the room and help everyone else, got it?”  
“Your teammate knows the answer...you may want to talk to her about it.”  
“Your teammate got it, so ask her!” |
There is a preponderance of research that demonstrates a positive correlation between the use of a variety of small-group instructional methods and enhanced engagement in learning and the development of critical thinking skills (Davidson & Major, 2014; Ginsburg-Block et al., 2006; Johnson & Johnson, 2009; Kagan, S., 2010; Rohrbeck et al., 2003; Tran, 2014). To increase my understanding of the relationship between time spent in small group work and student learning in Geometry classes, I recorded the amount of time students spent in small groups as well as the number of higher-order questions they asked and the number of instances of students analyzing and interpreting data/constructing alternative solutions to problems (Table 2 and Table 3). While I would have expected to see a greater number of higher-order questions and instances of students analyzing and interpreting data/constructing alternative solutions to problems in classes that spent more time in small group work, that was not the case. For example, the Geometry Regular class I observed spent the most minutes (compared to all of the other Geometry classes I observed) in small group work (25 minutes). While I observed the students in that class asking a total of 6 higher-order questions (which was the average number for all of Geometry classes I observed), I observed only 9 instances of students analyzing and interpreting data/constructing alternative solutions to problems. On the other hand, in the Geometry Honors class (class 1) that spent the least number of minutes in small group work (7 minutes), I observed the students asking 7 higher-order questions and I observed 33 instances (the highest number out of all of the Geometry classes I observed) of students analyzing and interpreting data/constructing alternative solutions to problems. In the two classes I observed
that did not spend any time in small group work (Geometry with Support, class 1 and class 2),
students asked no or a small number of higher order questions (0 and 3, respectively) and I
observed a relatively small number of instances of students analyzing and interpreting
data/constructing alternative solutions to problems (16 and 11, respectively). Because the
Geometry in Construction model has a strong emphasis on teamwork, I expected to observe a
significant number of minutes of class time devoted to small group work; however, that was not
the case (Figure 3 and Table 2).

Figure 3: Geometry Classroom Observations – Comparison of Time Spent in Whole Class,
Small Group, Peer Sharing, Or Individual Work

![Geometry Classroom Observations - Number of Minutes Spent in Whole Class, Small Group, Peer Sharing, or Individual Work](image_url)
Table 2: Geometry Classroom Observations -- Number of Minutes Spent in Whole Class, Small Group, Peer Sharing, or Individual Work; Total number of Instances of Students Asking Higher-Order Questions and Total number of Instances of Students Analyzing and Interpreting Data/Constructing Alternative Solutions to Problems

<table>
<thead>
<tr>
<th>Geometry Class (42 minute class periods)</th>
<th>Minutes Spent in Whole Class Instruction</th>
<th>Minutes Spent in Small Group Work</th>
<th>Minutes Spent in Peer Sharing Work</th>
<th>Minutes Spent in Individual Work</th>
<th>Number of instances of students asking higher-order questions</th>
<th>Number of instances of students verbally analyzing and interpreting data/constructing alternative solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry in Construction (class 1)</td>
<td>15</td>
<td>11</td>
<td>0</td>
<td>17</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Geometry in Construction (class 2)</td>
<td>30</td>
<td>9</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Geometry Honors (class 1)</td>
<td>33</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>33</td>
</tr>
<tr>
<td>Geometry Honors (class 2)</td>
<td>31</td>
<td>8</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>28</td>
</tr>
<tr>
<td>Geometry Honors (class 3)</td>
<td>20</td>
<td>21</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>Geometry Honors (class 4)</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Geometry Regular (class 1)</td>
<td>17</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Geometry With Support (class 1)</td>
<td>39</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Geometry With Support (class 2)</td>
<td>39</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>11</td>
</tr>
</tbody>
</table>

To increase my understanding of the extent to which students tended to ask higher order questions or verbally analyze and interpret data/construct alternative solutions to problems while working in small groups versus while they were participating in whole class instruction or discussion, I developed a comparison table (Table 3). Overall, I observed students asking more higher-order questions (21 total questions) when participating in whole class discussions than
when participating in small group discussions (16 total questions). I also observed more instances of students verbally analyzing and interpreting data/constructing alternative solutions to problems when participating in whole class discussions (127 total instances) than when participating in small group discussions (62 total instances). Because the *Geometry in Construction* model has a strong emphasis on teamwork, I expected to observe significantly more instances of students asking higher-order questions and significantly more instances of students verbally analyzing and interpreting data/constructing alternative solutions while in small groups; however, that was not the case.

Table 3: Geometry Classroom Observations -- Number of instances of students asking higher-order questions and verbally analyzing and interpreting data/constructing alternative solutions to problems during whole class discussion versus during small group work

<table>
<thead>
<tr>
<th></th>
<th>During Whole Class Discussion</th>
<th>During Small Group Work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of instances of students asking higher-order questions</td>
<td>Number of Instances of students verbally analyzing and interpreting data/constructing alternative solutions</td>
</tr>
<tr>
<td>Geometry in Construction (class 1)</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Geometry in Construction (class 2)</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Geometry Honors (class 1)</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Geometry Honors (class 2)</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Geometry Honors (class 3)</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Geometry Honors (class 4)</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Geometry Regular (class 1)</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Group work (as opposed to more formal or informal cooperative learning) has been shown to lead to problems such as unequal participation and lower levels of engagement by all students (Kagan & Kagan, 2009). To examine the quality of group work during my observations of Geometry classes, I specifically focused on one small group in each class to look for participation patterns. For each student in the specific small group, I recorded demographic information and the number of times she/he verbally participated in the small group discourse (Table 4). I also noted instances where one student served as an informal discussion leader. Of the small groups I observed, those in Geometry in Construction (class 2) and Geometry Honors (class 2) had the most evenly balanced participation. In the small group I observed in Geometry Honors (class 4), the discussion was dominated by one student (a White female). The small group I observed in Geometry Honors (class 1) was characterized by very little participation of any of the group members. One student was informally leading the group discussion in 4 of the 7 small groups I observed including the group in Geometry in Construction (class 1- led by a White female student), Geometry in Construction (class 2 - led by a Black female student), Geometry Honors (class 4 - led by a White female student), and Geometry Regular (class 1 - led by a Black male student).
Table 4: Geometry Classroom Observations -- Observation of One Small Group During Minutes Spent in Small Group Work

<table>
<thead>
<tr>
<th>Geometry Class</th>
<th>Minutes Spent in Small Group Work</th>
<th>Number of times each student verbally participated in observed small group (* indicates student served as informal discussion facilitator)</th>
</tr>
</thead>
</table>
| Geometry in Construction (class 1) | 11                                | Group of 3 students: Student #1 - Black Female -- 5 times  
|                                 |                                   | *Student #2 - White Female -- 4 times  
|                                 |                                   | Student #3 - Hispanic Female -- 2 times |
| Geometry in Construction (class 2) | 9                                 | Group of 4 students:  
|                                 |                                   | *Student #1 - Black Female - 7 times  
|                                 |                                   | Student #2 - Black Female - 8 times  
|                                 |                                   | Student #3 - White Male - 5 times  
|                                 |                                   | Student #4 - White Male - 9 times |
| Geometry Honors (class 1)       | 7                                 | Group of 4 students:  
|                                 |                                   | Student #1 - White Female - 0 times  
|                                 |                                   | Student #2 - White Female - 3 times  
|                                 |                                   | Student #3 - White Female - 0 times  
|                                 |                                   | Student #4 - White Female - 2 times |
| Geometry Honors (class 2)       | 8                                 | Group of 4 students:  
|                                 |                                   | Student #1 - White Male - 6 times  
|                                 |                                   | Student #2 - White Male - 7 times  
|                                 |                                   | Student #3 - White Female - 7 times  
|                                 |                                   | Student #4 - White Female - 4 times |
| Geometry Honors (class 3)       | 21                                | Group of 4 students:  
|                                 |                                   | Student #1 - White Female - 7 times  
|                                 |                                   | Student #2 - White Male - 4 times  
|                                 |                                   | Student #3 - White Male - 3 times  
|                                 |                                   | Student #4 - Black Female - 2 times |
| Geometry Honors (class 4)       | 20                                | Group of 3 students:  
|                                 |                                   | *Student #1 - White Female - 12 times  
|                                 |                                   | Student #2 - White Male - 6 times  
|                                 |                                   | Student #3 - White Male - 3 times |
| Geometry Regular (class 1)      | 25                                | Group of 4 students:  
|                                 |                                   | *Student #1 - Black Male - 5 times  
|                                 |                                   | Student #2 - Hispanic Male - 4 times  
|                                 |                                   | Student #3 - Hispanic Female - 2 times  
|                                 |                                   | Student #4 - Hispanic Female - 0 times |
| Geometry With Support (class 1) | 0                                 | No groups observed.  
| Geometry With Support (class 2) | 0                                 | No groups observed.  

To summarize, I did not find significant differences in the use and impact of cooperative learning in *Geometry in Construction* classes versus other Geometry classes at WTHS. Overall, I observed students engaged in small group work as opposed to cooperative learning, including in Geometry in Construction classes. In the class periods I observed, the amount of time and quality of small group work for students in *Geometry in Construction* was not significantly
different than the amount of time and quality of small group work in other Geometry classes (except for the Geometry with Support classes which spent no time in small group work). Combining all of my Geometry classroom observations together, I observed more instances of students asking higher order questions and instances of students verbally analyzing and interpreting data/constructing alternative solutions to problems when participating in whole class discussions versus while they were engaged in small group work. Of the individual small groups I observed within 7 Geometry classrooms (including Geometry in Construction), there was generally even participation of group members except for one group in a Geometry Honors class which was dominated by a White female student (she verbally participated 12 times versus other group members who participated half and one-third as often respectively).

The secondary focus for this program evaluation was to determine the extent to which students enrolled in Geometry in Construction perceived their attainment of 21st century skills (particularly those related to teamwork and collaboration) differently than students enrolled in other Geometry classes at WTHS. To investigate my secondary focus, I reviewed the data from the retrospective pretest given to all Geometry students at WTHS during the 2016-2017 school year (Appendix A). This survey was developed and administered by the WTHS Research and Evaluation department.

As part of the survey, students were asked to read and reflect on statements that pertained to their current math class. This section of the survey was not a part of the retrospective pretest. They were directed to place an x in the box that reflected how true a statement was. Three of these statements related specifically to the 21st century skills of collaboration and teamwork including: My teacher(s) give me the opportunity to lead groups, My teacher(s) give me time to work with other students, and My teacher(s) encourage me to consider the opinions of
The results of this section of the survey are summarized in Table 5. The results from these three statements were found to be statistically significant (chi-square < .05).

Table 5: 2016/17 Geometry Student Survey Results (Current Math Class - 21st Century Skills) - % of Students Selecting About 75% of the time or About 100% of the time

<table>
<thead>
<tr>
<th></th>
<th>GiC</th>
<th>Geometry Support</th>
<th>Geometry Regular</th>
<th>Geometry Honors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Respondents</td>
<td>75</td>
<td>118</td>
<td>219</td>
<td>207</td>
</tr>
<tr>
<td>My teacher(s) give me the opportunity to lead groups. *</td>
<td>69%</td>
<td>48%</td>
<td>54%</td>
<td>60%</td>
</tr>
<tr>
<td>My teacher(s) help me organize my time.</td>
<td>64%</td>
<td>69%</td>
<td>62%</td>
<td>57%</td>
</tr>
<tr>
<td>My teacher(s) give me time to work with other students. *</td>
<td>92%</td>
<td>83%</td>
<td>88%</td>
<td>95%</td>
</tr>
<tr>
<td>My teacher(s) encourage me to ask questions. *</td>
<td>88%</td>
<td>80%</td>
<td>75%</td>
<td>88%</td>
</tr>
<tr>
<td>My teacher(s) encourage me to consider the opinions of others. *</td>
<td>84%</td>
<td>73%</td>
<td>73%</td>
<td>84%</td>
</tr>
<tr>
<td>My teacher(s) help me set goals for myself</td>
<td>72%</td>
<td>72%</td>
<td>61%</td>
<td>67%</td>
</tr>
</tbody>
</table>

*chi-square<.05

Sixty-nine percent of Geometry in Construction students selected about 75% of the time or about 100% of the time when responding to the statement My teacher(s) give me the opportunity to lead groups compared to 60 percent of students in Geometry Honors, 54 percent in Geometry Regular, and 48 percent in Geometry with Support. Because students in Geometry in Construction divide their time equally between Geometry days and Construction days, the opportunity for students to lead groups may occur on Construction days rather than Geometry days. Based on my limited observations of Geometry classes, the lower percentage of Geometry with Support students responding positively to the statement regarding their teachers giving them the opportunity to lead groups may be based on the limited time students are engaged in group work.
In terms of students indicating that they have time to work with other students in their Geometry class, 92 percent of Geometry in Construction students selected \textit{about 75\% of the time} or \textit{about 100\% of the time} when responding to the statement \textit{My teacher gives me time to work with other students}. A slightly higher percentage of students (95 percent) in Geometry Honors selected \textit{about 75\% of the time} or \textit{about 100\% of the time} when responding to the statement \textit{My teacher gives me time to work with other students}. The high level of agreement for students in Geometry in Construction may be because students in the class are always organized into small groups or teams on Construction days. The high level of agreement for students in Geometry Honors classes may be a reflection of the fact that, based on my observations, Geometry Honors classes are physically arranged for small group work and students routinely engage in informal group work.

Because collaboration is an important 21st century skill, I found student responses to the statement \textit{My teacher(s) encourage me to consider the opinions of others} to be particularly important. Based on the fact that the only collaborative learning I observed in any of the Geometry classes was group work (as opposed to formal cooperative learning), the responses to the statement may be based on encouragement provided to students during whole class discussions as well as during small group work. Eighty-eight percent of Geometry in Construction students and Geometry Honors students selected \textit{about 75\% of the time} or \textit{about 100\% of the time} when responding to this statement, followed by 73 percent of students in Geometry Regular and Geometry with Support.

I also analyzed data from the student responses to 4 (out of a total of 11) of the 21st Century Skills retrospective pretest statements related to collaboration and teamwork (Table 6). The statements are as follows: \textit{I lead others to accomplish a goal}, \textit{Others can count on me to...}
accomplish a goal, I listen to what others say before acting, I think about how others see things. For this part of the survey, students are instructed to read each statement, think about how true the statement is for them today, and then think about how true the statement was for them before they took their current math class. It also instructs them to think about their overall experience in life when responding to the statements. The pre- versus post- mean for Geometry in Construction student responses and for students in all of the other Geometry classes combined met the standard for statistical significance @ .05 for all 4 of these statements. Regarding the statement, I lead others to accomplish a goal, the percentage of Geometry in Construction students who indicated that the statement was often or almost always true for them increased (from pre to post) by 14 percent. This is 8 percentage points higher than the increase for all other Geometry students indicating that the statement was often or almost always true for them from pre to post. Regarding the statement Others can count on me to accomplish a goal, the percentage of Geometry in Construction students who indicated that the statement was often or almost always true for them increased (from pre to post) by 15 percent. This is 5 percentage points higher than the increase for all other Geometry students indicating that the statement was often or almost always true for them from pre to post. The pre to post change in the percentage of Geometry in Construction students (13 percent change) and all other Geometry students (15 percent change) indicating that the statement, I listen to what other say before acting was often or almost always true for them was similar. Lastly, regarding the statement I think about how others see things, the percentage of Geometry in Construction students who indicated that the statement was often or almost always true for them increased (from pre to post) by 17 percent. This is 6 percentage points higher than the increase for all other Geometry students indicating that the statement was often or almost always true for them from pre to post.
Table 6: 2016-17 Geometry Student Survey Results (21st Century Skills -- Retrospective Pre-Test Statements Related to Collaboration and Teamwork - Geometry in Construction (GiC) Compared to All Other Geometry Classes Combined

<table>
<thead>
<tr>
<th></th>
<th>GiC Pre</th>
<th>GiC Post</th>
<th>Difference Pre to Post</th>
<th>Geometry Other - Pre</th>
<th>Geometry Other - Post</th>
<th>Difference Pre to Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Students</td>
<td>68</td>
<td>68</td>
<td>507</td>
<td>507</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I lead others to accomplish a goal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost Never</td>
<td>4%</td>
<td>1%</td>
<td>9%</td>
<td>8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seldom True</td>
<td>18%</td>
<td>15%</td>
<td>19%</td>
<td>15%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes True</td>
<td>31%</td>
<td>23%</td>
<td>27%</td>
<td>27%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often True</td>
<td>31%</td>
<td>42%</td>
<td>29%</td>
<td>34%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost Always True</td>
<td>16%</td>
<td>19%</td>
<td>15%</td>
<td>15%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often + Almost Always true</td>
<td>47%</td>
<td>61%</td>
<td>+14%</td>
<td>44%</td>
<td>50%</td>
<td>+6%</td>
</tr>
<tr>
<td>Mean</td>
<td>3.3676</td>
<td>3.6324</td>
<td>+.2648</td>
<td>3.2091</td>
<td>3.3373</td>
<td>+.1282</td>
</tr>
<tr>
<td>Total Number of Students</td>
<td>75</td>
<td>75</td>
<td>532</td>
<td>532</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others can count on me to accomplish a goal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost Never</td>
<td>3%</td>
<td>3%</td>
<td>4%</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seldom True</td>
<td>8%</td>
<td>5%</td>
<td>10%</td>
<td>8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes True</td>
<td>21%</td>
<td>9%</td>
<td>24%</td>
<td>17%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often True</td>
<td>43%</td>
<td>44%</td>
<td>36%</td>
<td>40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost Always True</td>
<td>25%</td>
<td>39%</td>
<td>27%</td>
<td>33%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often + Almost Always true</td>
<td>68%</td>
<td>83%</td>
<td>+15%</td>
<td>63%</td>
<td>73%</td>
<td>+10%</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>3.8000</td>
<td>4.1067</td>
<td>+.3066</td>
<td>3.7256</td>
<td>3.9396</td>
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<tr>
<td>-------------------------------</td>
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<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td><strong>Total Number of Students</strong></td>
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<td>74</td>
<td>74</td>
<td>528</td>
<td>528</td>
<td></td>
</tr>
<tr>
<td><strong>I listen to what others say before acting.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost Never</td>
<td></td>
<td>1%</td>
<td>1%</td>
<td>4%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Seldom True</td>
<td></td>
<td>8%</td>
<td>1%</td>
<td>11%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Sometimes True</td>
<td></td>
<td>19%</td>
<td>12%</td>
<td>26%</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>Often True</td>
<td></td>
<td>34%</td>
<td>42%</td>
<td>29%</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td>Almost Always True</td>
<td></td>
<td>38%</td>
<td>43%</td>
<td>31%</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Often + Almost Always True</td>
<td></td>
<td>72%</td>
<td>85%</td>
<td>60%</td>
<td>75%</td>
<td>+15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>3.9865</th>
<th>4.2432</th>
<th>+.2567</th>
<th>3.7261</th>
<th>4.0511</th>
<th>+0.325</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Number of Students</strong></td>
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<td>73</td>
<td>73</td>
<td>529</td>
<td>529</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>I think about how others see things.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost Never</td>
<td></td>
<td>3%</td>
<td>1%</td>
<td>6%</td>
<td>3%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seldom True</td>
<td></td>
<td>8%</td>
<td>4%</td>
<td>9%</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes True</td>
<td></td>
<td>21%</td>
<td>9%</td>
<td>22%</td>
<td>18%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often True</td>
<td></td>
<td>34%</td>
<td>45%</td>
<td>31%</td>
<td>34%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost Always True</td>
<td></td>
<td>34%</td>
<td>40%</td>
<td>32%</td>
<td>41%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often + Almost Always True</td>
<td></td>
<td>68%</td>
<td>85%</td>
<td>63%</td>
<td>74%</td>
<td>+11%</td>
<td></td>
</tr>
</tbody>
</table>

GiC - Pre vs Post - mean - significantly different @ .05; Geometry Other - Pre vs Post - mean - significantly different @ .05 (cite)
In summary, a higher percentage of students in Geometry in Construction and in all other Geometry classes combined indicated that they believed these four 21st Century statements were often or almost always true for them at the end of the school year than what they indicated to be true for themselves before they took their current math class. For three out of the four statements, the increase from pre to post was higher for Geometry in Construction students.
SECTION FIVE: JUDGMENT AND RECOMMENDATIONS

As I stated earlier in this program evaluation, my overall goal was to focus on the interconnection between *Geometry in Construction’s* use of cooperative learning strategies and students’ development of the important 21st century skill of collaboration. While I had hoped my research findings would illuminate important differences between *Geometry in Construction* and other Geometry classes, the findings were decidedly mixed and provided me with more questions than answers. For example, the classroom observations I completed did not reveal significant differences in the amount of time spent in cooperative learning groups, nor in the quality of small group work, in *Geometry in Construction* versus other Geometry classes at WTHS (with the exception of Geometry with Support classes). In addition, the results of the retrospective pretest showed a higher percentage of all students in Geometry (*Geometry in Construction* and in all other Geometry classes combined) indicating that they believed the four 21st Century statements related to teamwork and collaboration were often or almost always true for them at the end of the school year than what they believed to be true for themselves before they took their current Geometry class. However, it was encouraging that for three of the four statements, the increase from pre to post was higher for *Geometry in Construction* students. Perhaps the most positive finding was the high percentage of *Geometry in Construction* students agreeing that their teacher(s) gave them the opportunity to lead groups, time to work in groups, and encouraged them to consider the opinions of others. While Geometry Honors students had similarly high agreement with these statements, the agreement level for *Geometry in Construction* students (69%) was higher than Geometry Honors students (60%) regarding the statement *My teacher(s) give me the opportunity to lead groups.*
Given these findings, I believe that more research needs to be done to highlight and pinpoint the relationship between enrollment in *Geometry in Construction* and the development of the 21st century skills of collaboration and teamwork. In particular, I would recommend gathering additional data regarding students’ experiences working in teams to complete the construction of the house.

Another important aspect of this research is an increased awareness of the type of cooperative learning being used in many Geometry classes. While students were seated in small group arrangements in the majority of classes I observed, I did not observe any instances of formal cooperative learning (Johnson, Johnson, & Holubec, 2008). What I did observe were small groups of students quickly (and sometimes unevenly) responding to a prompt from the teacher. While informal group work is considered to be a form of cooperative learning (Johnson, Johnson, & Holubec, 2008), its usefulness as a means of increasing student achievement and building collaboration skills is limited since it does not incorporate the development of group goals and lacks the mechanisms for individual accountability that are optimal for learning (Slavin, 2011). In fact, I think it is possible to conclude that the informal and unstructured nature of the group work I observed contributed to the relatively smaller number of instances of students asking higher order questions and verbally analyzing and interpreting data/constructing alternative solutions to problems while participating in small group work. Of equal if not more importance is the fact that no group work was observed in Geometry with Support classes. If, in fact, cooperative learning is a recommended strategy for improving mathematics education for all students (Boaler, 2016; Esmonde, 2009; Shafer, 2016), the absence of the use of the strategy in Geometry classes for our most struggling math students is problematic. My observations of Geometry classes, combined with the body of research highlighted in this report which
illuminates the many benefits of the use of cooperative learning strategies (particularly in math classrooms), lead me to conclude that we need to develop a plan to help teachers learn more about and increase the use of cooperative learning strategies which will lead to increased student achievement and collaboration skills.

Regarding the use of certain research methods, completing this program evaluation increased my understanding of the limitations and potential benefits of both the classroom observation protocol and the retrospective pretest. While I am a very experienced classroom observer (having observed teachers for evaluation purposes in a variety of departments over the past 15 years), I found that completing a singular classroom observation of a particular classroom was limiting for the purpose of program evaluation. I believe my findings and conclusions would have benefited from multiple, consecutive observations in the same mathematics classrooms as this would have provided a more complete picture of overall classroom dynamics, the teacher’s use of small groups for instruction, and patterns of individual student participation while in small groups. Alternatively, the Geometry Classroom Observation Tool that I developed specifically for the Geometry classroom observations provided me with additional ideas of ways to organize and draw conclusions from the myriad classroom observations that I and other administrators complete each year. I found the process of coding and analyzing aspects of classroom dynamics (for example, numbers of higher order questions asked) to be a useful tool that could be used to analyze other aspects of teaching and learning. I plan to share this aspect of my research protocol with other department chairs and administrators in hopes that we can use this method to capture additional important information about the lived experience of teachers and students in classrooms.
Similarly, I was not completely satisfied with the retrospective pretest developed for and administered to Geometry students at the end of the 2017 school year. Although the retrospective pretest findings were favorable in terms of the percentages of Geometry in Construction students who indicated that they believed their 21st Century skills (related to collaboration and teamwork) had increased from the beginning to the end of the year, the same was true for students enrolled in all of the other Geometry classes combined. The fact that for three out of the four collaboration/teamwork statements, the increase from pre to post was higher for Geometry in Construction students than for other Geometry students combined points to something positive happening in Geometry in Construction. However, beyond that it is difficult to draw specific conclusions from the data generated by the retrospective pretest. This may reflect overall challenges that have been identified regarding the use of the retrospective pre-test (Colosi & Dunifon, 2006) including difficulties in accurately recalling attitudes and behaviors from the past, a bias toward reporting change or improvement to program (or in this case, teacher) expectations, and participants reporting improvement to meet their own expectation that they should have changed. In addition, the wording of the instructions for the 21st century skills section of the retrospective pretest may have made it difficult to ascertain the extent to which students in Geometry in Construction were considering the statements based specifically on their experience on Geometry days versus Construction days in their Geometry in Construction class. I also believe that the 21st century statements used in the retrospective pretest should be reviewed and possibly revised to more accurately reflect specific and perhaps additional attributes of collaboration and teamwork. That being said, I believe the retrospective pretest provides an efficient and economical way to increase our understanding of students’ perceptions.
of their own growth in 21st century skill development and I hope that we will expand its use to other classes and/or cohorts of students.

In closing, completion of this project has increased my capacity to understand all aspects of program evaluation including the need to include the perspectives of multiple stakeholders, how to develop specific and meaningful research questions, how to determine the best research methods to generate the data that will answer these research questions, and the importance of careful and systematic planning (Patton, 2008).
References


NBC Nightly News [Television broadcast]. (2018, June). In geometry in construction helps students learn by building houses. NBC. Retrieved November 15, 2018 from
https://www.nbcnews.com/nightly-news/video/-geometry-in-construction-helps-students-
learn-by-building-houses-1247410755701


Appendix A -- 2016-2017 Algebra/Geometry Student Survey

### 2016-17 1 Algebra/Geometry Student Survey

Your teachers and the school’s administrators are interested in knowing a little more about you and your experiences with math. Your responses will be confidential and will not be singled out. In other words, individual responses will not be shared with anyone else and we will review everyone’s answers together.

Please print your Student ID number: ____________

**What math course are you currently taking?**
- [ ] 1 Algebra
- [ ] Algebra in Entrepreneurship
- [ ] Geometry in Construction
- [ ] Geometry with Support
- [ ] Geometry
- [ ] Geometry H

When responding to items 1 - 6, please think about the *math class you are taking now*. Please read each statement and place an X in the box that reflects how true the statement is.

**IN YOUR CURRENT MATH CLASS...**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Statement</th>
<th>Almost never true</th>
<th>Seldom true</th>
<th>Sometimes true</th>
<th>Often true</th>
<th>Almost always true</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>My teacher(s) give me the opportunity to lead groups.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>My teacher(s) help me organize my time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>My teacher(s) give me time to work with other students.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>My teacher(s) encourage me to ask questions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>My teacher(s) encourage me to consider the opinions of others.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>My teacher(s) help me set goals for myself.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Instructions for completing items 7-19: Each item has three parts.
Part 1: Read the STATEMENT in the center column.
Part 2: Think about the statement and how you feel about that statement today. Place an X in the box that reflects your CURRENT level of agreement.
Part 3: Think about the statement again and how you felt about that statement before you took this math course. Place an X in the box that reflects your level of agreement BEFORE THIS MATH COURSE.

When responding to items 7-19, please think about your overall experience with math and not just this class.

<table>
<thead>
<tr>
<th>ITEM NO.</th>
<th>CURRENT</th>
<th>BEFORE THIS MATH COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item No.</td>
<td>CURRENT</td>
<td>BEFORE THIS MATH COURSE</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>------------------------</td>
</tr>
<tr>
<td></td>
<td>Strongly disagree</td>
<td>Disagree</td>
</tr>
<tr>
<td>17.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I like the challenge of math.</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I don’t expect to use much math when I get out of school.</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Math is a worthwhile and necessary subject.</td>
<td></td>
</tr>
</tbody>
</table>

Instructions for completing items 20-31: Each item has three parts.

Part 1: Read the STATEMENT in the center column.

Part 2: Think about the statement and how you true that statement is about you today. Place an X in the box that reflects your CURRENT level of truth.

Part 3: Think about the statement again and how you true that statement was about you before you took this math course. Place an X in the box that reflects your level of truth BEFORE THIS MATH COURSE.

When responding to items 20-31, please think about your life overall.

YOUR OVERALL EXPERIENCE IN LIFE

<table>
<thead>
<tr>
<th>Item No.</th>
<th>CURRENT</th>
<th>BEFORE THIS MATH COURSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Almost never true of me</td>
<td>Seldom true of me</td>
</tr>
<tr>
<td>20.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I lead others to accomplish a goal.</td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Team members can count on me.</td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Others can count on me to accomplish a goal.</td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>I put all my energy into accomplishing my goals.</td>
<td></td>
</tr>
<tr>
<td>Item No.</td>
<td>CURRENT</td>
<td>BEFORE THIS MATH COURSE</td>
</tr>
<tr>
<td>---------</td>
<td>---------</td>
<td>-------------------------</td>
</tr>
<tr>
<td></td>
<td>Almost never true of me</td>
<td>Seldom true of me</td>
</tr>
<tr>
<td>24.</td>
<td>I push myself.</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>I listen to what others say before acting.</td>
<td></td>
</tr>
<tr>
<td>26.</td>
<td>I think about how others see things.</td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>I can adjust to change.</td>
<td></td>
</tr>
<tr>
<td>28.</td>
<td>I am open to change.</td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td>I use creativity and ideas to make things happen.</td>
<td></td>
</tr>
<tr>
<td>30.</td>
<td>I can solve problems in different ways.</td>
<td></td>
</tr>
<tr>
<td>31.</td>
<td>I know how to find the information that I need and who to ask for help.</td>
<td></td>
</tr>
</tbody>
</table>

Thank you very much for taking this survey!
Appendix B - Geometry Classroom Observation Tool

Course: ____________________ Period: _________________ Number of Minutes Observed: _____________

Geometry Classroom Observation Tool Focus: student engagement and use of 21st century skills (teamwork, curiosity, communication, creativity, critical thinking)

Evidence of Effective Engagement -- 1. active participation and sustained attention 2. Evidence of Meaningful Peer Interactions -- peer sharing and group work 3. Evidence of Higher-Order Thinking (identifying and investigating problems/questions; examining, analyzing, and/or interpreting data, information, and/or approaches; constructing alternatives, predicting, hypothesizing, or brainstorming; developing arguments, providing explanations)

List examples of student engagement here:

Document the amount of time spent in this form of instruction and estimate the number of students on task and participating during:

Whole class: ________/_________
Small group: ________/_________
Peer sharing: ________/_________
Individual: ________/_________

List examples of students engaged in peer sharing and/or group work here:

Note the number of minutes of sustained peer-to-peer or small group collaborative work:

__________________________________

Observe one set of peers or one small group and tally the number of times each student participates:

Student 1 ___________________
Student 2 ___________________
Student 3 ___________________
Student 4 ___________________

Place an * next to any student who facilitated the discussion/completion of work

Are students engaged in higher-order thinking? Tally the number of instances of:

Students asking higher-order questions
Students analyzing and interpreting data/information/approaches
Students constructing alternative solutions, predicting, hypothesizing, brainstorming
Students developing arguments or providing explanations