An Experimental Comparison of Student Motivation Between Two Computational Thinking-Based STEM Activities: Vex-Based Automation and Robotics and a Quadcopter Activity

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AN EXPERIMENTAL COMPARISON OF STUDENT MOTIVATION BETWEEN
TWO COMPUTATIONAL THINKING-BASED STEM ACTIVITIES:
VEX-BASED AUTOMATION AND ROBOTICS AND A
QUADCOPTER ACTIVITY

by

Cory J. Ortiz

A thesis submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Technology and Engineering Education

Approved:

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UTAH STATE UNIVERSITY
Logan, Utah

2018
ABSTRACT

An Experimental Comparison of Student Motivation Between Two Computational Thinking-Based STEM Activities: VEX-Based Automation and Robotics and a Quadcopter Activity

by

Cory J. Ortiz, Master of Science
Utah State University, 2018

Major Professor: Gary Stewardson, Ph.D.
Department: Applied Sciences Technology Education

The purpose of this study was to compare curricular motivation between two computational thinking based STEM curriculums. The two different STEM curriculum studied were a newly developed quadcopter curriculum based around four units (safety, manual flight, autonomous flight, and data acquisition), and a unit out of the Project Lead the Way’s Gateway to Technology, Automation and Robotics course. Motivation was defined by the My Class Activities assessment through the constructs of interest challenge, choice, and enjoyment.

This study examined the hypothesis that students are more motivated by quadcopter curriculum than Project Lead the Way VEX robotics curriculum. One-hundred three eighth-grade students in three different classrooms who were enrolled in Project Lead the Way’s, Automation and Robotics course in a northern Utah suburban
school district participated in this study. All students received the entirety of both
curricular activities in a counterbalanced fashion. Students were assessed at the end of
each curriculum using the My Class Activities assessment. The My Class Activities
assessment gauged student’s motivation through the constructs of interest, challenge,
choice, and enjoyment towards computational thinking based curriculum rather than
assessing explicit computational thinking skills. Data were then coded and analyzed using
a 2 x 3 repeated measures ANOVA where factor one was the curricular exercise and
factor two was the teacher delivering the curriculum.

The results of this study suggest that though the VEX robotics curriculum offered
statistically more challenge and choice for students, the teacher in the classroom
delivering the curriculum had more to do with student motivation than the curriculum
itself.
PUBLIC ABSTRACT

An Experimental Comparison of Student Motivation Between Two Computational Thinking-Based STEM Activities: VEX-Based Automation and Robotics and a Quadcopter Activity

Cory J. Ortiz

The purpose of this study was to compare student motivation between two junior high level computational thinking based STEM curricular activities. These two activities were a newly developed quadcopter based curriculum and a VEX based curricular activity developed for Project Lead the Way’s Gateway to Technology – Automation and Robotics course. Student motivation was assessed using an assessment called My Class Activities which broke motivation into four constructs: interest, challenge, choice, and enjoyment.

This study assessed students in three schools in a northern Utah school district. Students were assessed after receiving each curriculum. Assessment responses were then coded and analyzed. The results of this study suggested that though the junior high VEX curriculum was more challenging and offered students more choice than the quadcopter curriculum, the teacher delivering the curriculum had more to do with student motivation.
ACKNOWLEDGMENTS

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I would also like to thank my family and friends for all of their support. Without the support of my wife, Molly, and my parents, Jay and Ellen Ortiz, I would not have been able to finish this project. Thank you for your understanding and sacrifices made in helping me in my educational pursuits.

Cory J. Ortiz
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CHAPTER I
INTRODUCTION

In an effort to keep up with the ever more technologically sophisticated world, skills such as computational thinking have become the subject of global interest. In fact, *The Link*, a publication out of the School of Computer Science at Carnegie Mellon University listed computational thinking as an essential component of 21st century literacy (Togyer & Wing, n.d.). Because of this, companies and educational institutions are working to integrate computational thinking into all levels of education as an effort to teach complex thinking and problem solving. At its basic roots, computational thinking revolves around concepts such as abstraction, decomposition, algorithm design, and pattern recognition which scholars believe are essential skills applicable across disciplines (Google, n.d.). Classroom activities can be targeted at developing computational thinking skills through complex problem solving. These complex problems are logical in nature and have more than one correct answer. While many computational thinking activities are deeply rooted in programming, motivating activities such as robotics can be leveraged to highlight key aspects of computational thinking through a use-modify-create learning progression (Lee et al., 2011).

With the push in schools to teach 21st century skills like computational thinking, schools are moving to leverage motivating tools such as Unmanned Aerial Vehicles (UAVs) as a learning tool. A programmable UAV can be characterized simply as a three dimensional robot that is capable of movement through Cartesian Coordinates X, Y, and Z axis, lending themselves to be optimized as next generation technology in place of
traditional robots. Unmanned Aerial Vehicles are becoming so commonplace, that companies such as Amazon claim that they will be as common as seeing traditional mail delivery trucks (Matyszczyk, 2015). In recent years, UAVs have infiltrated industries such as surveying, inspections, science, security, situational monitoring, search and rescue, cargo delivery, aerial video and photography with emerging applications in logistics, first aid, agriculture, and mining (Microdrones, n.d.). With the boom in the UAV industry, a need to prepare students for careers in UAVs becomes apparent. With estimates of thousands of new UAV operator jobs being added to the economy soon after the Federal Aviation Administration formally integrates UAVs into the National Airspace, schools are working to find ways to train students on the utilization of UAVs (Jenkins & Vasigh, 2013).

Educators have a unique opportunity to capitalize on the wide applications of UAV technology in their classrooms. Specifically, students and teachers alike have found quadcopters, a smaller, more affordable type of four prop helicopter, motivating in formal and informal classroom settings. In recent years, regional workshops that focus on utilizing quadcopters in the classroom have been the first to fill and are always requested back (G. Stewardson, personal communication, October 23, 2017). After school drone programs often become the most popular after school program in the school (Cook, 2017). In the formal classroom setting, drones have been used as a method of teaching coding though hands on and engaging lessons (Hussey, 2017). Through the unique motivation generated by UAVs in the classroom, teachers are beginning to leverage drones to effectively teach essential 21st century skills.
Statement of the Purpose

The purpose of this study was to compare two different computational thinking based STEM curricula using student motivation as defined by the *My Class Activities* assessment (Gentry & Gable, 2001) as a measure of curriculum effectiveness to motivate students. Specifically, this study compared Project Lead the Way automation based curricular activities and a recently developed activity utilizing quadcopters.

Statement of the Need

Developing motivational and effective curriculum around UAVs serves many needs. According to economic projections, the United States will need approximately one million more STEM professionals than the U.S. will produce at the current rate over the next decade (Holdren & Lander, 2012). Interest regarding quadcopters by teachers and students alike offer a unique opportunity to teach complex, real-world, 21st century skills to learners in a fashion that may attract more students to STEM disciplines. With the various applications of UAV technology, teachers can use drones to teach skills such as coding, computational thinking, piloting, design, and more (Parrot, n.d.). Attributable to the growing UAV industry, many companies have begun hiring UAV pilots. Exposing students to UAVs in the classroom allows for exploration in a technology that could lead to meaningful employment.

Alongside the rapid development of UAV technology is the need for more robust, relevant, and motivational curriculum focused on developing 21st century skills such as computational thinking. According to Wing (2006), computational thinking is an
essential skill on par with reading, writing, and arithmetic. Wing stated that computational thinking is not about computer programming or rote skill but rather the skills utilized as we apply abstraction and decomposition to solve problems and design solutions. Skills such as computational thinking are essential for the upcoming generation as they will be required to work in fields that do not yet exist and solve problems that are not yet known.

With UAV technology becoming more affordable, educational institutions are working to leverage student interest in UAVs in the classroom in an effort to teach complex problem solving and coding skills while keeping ahead of the growing need for trained UAV operators. Much like industry, youth and teachers alike are gravitating towards UAVs at a rapid pace. Schools that have incorporated UAVs into their classroom curriculum generate enough interest, that students come before and after school to learn with them (Bahou, 2017).

In an effort to create a more relevant curriculum geared towards developing 21st century skills, leveraging student interest, and the growing UAV industry, a curriculum was developed as a part of Jordan Bartholomew’s and Russ Mayo’s Masters project conducted at Utah State University (Bartholomew & Mayo, 2018). Throughout the curriculum, students are tasked with manually flying, programming, and using the UAV as a vehicle to remotely acquire temperature and luminosity data. During the programming lessons, students have to piece together the logic of navigating the UAV through an obstacle course. During the data acquisition portion of the curriculum, students have to design and fabricate a bracket to hold a data acquisition package onto the
robot, then use the sensor data to identify specific attributes about field elements. The curriculum is focused on exposing students to flight principles, programming, and data acquisition.

There is a need to teach complex skills such as computational thinking as the 21st century is bound to bring defining problems that the upcoming generation will have to solve. The younger generation needs to be prepared to solve complex problems that are not yet known. By leveraging motivational technology, such as UAVs, teachers can more effectively teach essential 21st century skills.

Research Question and Null Hypothesis

This study has examined the following research question.

1. Are middle school students more motivated as measured by the My Class Activities curriculum effectiveness assessment when learning with a recently developed quadcopter based activity than with traditional Project Lead the Way robotics curriculum?

This will be tested against the null hypothesis that there is no motivational difference between Project Lead the Way’s Automation and Robotics curricular activities and quadcopter-based activities.

Assumptions

The following assumptions were made in the pursuit of this study:

1. Students have responded honestly to the curriculum effectiveness assessment.
2. All STEM based lessons were taught with minimal teacher bias.
3. Curriculum was the same or similar in difficulty level.
4. Teachers self-efficacy is similar.

5. Teachers have a similar teaching style.

6. Teachers followed the curriculum model to the same degree and had equitable engagement.

7. Teachers content knowledge and pedagogical practices are similar.

Limitations

The following limitations were identified while conducting this study:

1. This study was limited to middle school students in a suburban school district in northern Utah.

2. This study was limited to comparing only within Project Lead the Way, Automation and Robotics curricular activities and the newly developed quadcopter activity.

3. This study was limited in the number of teachers and students engaged in the curriculum.

Summary of the Procedure

Students who participated in this study completed pre- and post-tests measuring student’s perceptions of challenge, choice, interest, and enjoyment as defined by the MyClass Activities curriculum effectiveness assessment. The following steps were performed in the pursuit of this study.

1. A problem was identified showing a need for a study comparing student perceptions between Project Lead the Way’s Automation and Robotics activities and a recently developed quadcopter activity.

2. A review of literature was performed to determine what research currently addressed the problem and what additional research was needed.

3. A curriculum effectiveness assessment capable of measuring student
motivation though the constructs of challenge, choice, interest, and enjoyment was identified (*My Class Activities.*)

4. An appropriate student test population was identified in the region.

5. An appropriate design for the study was determined.

6. A formal proposal for the study was written.

7. Communication regarding the study was established with the teacher participants.

8. Approval to perform the research study was obtained from the Institutional Review Board (IRB) for the protection of human subjects at Utah State University. See Appendix A for IRB Certificate of Exemption.

9. Teachers were trained in the delivery of the newly developed quadcopter curriculum to insure consistency in lesson delivery.

10. Participating students were separated into two groups, group one and group two. Group one was taught Project Lead the Way curriculum first while group two was taught the newly developed quadcopter curriculum first.

11. The *My Class Activities* curriculum effectiveness assessment was administered to students in group one following the teaching of an activity out of Project Lead the Way Automation and Robotics curriculum.

12. The *My Class Activities* curriculum effectiveness assessment was administered to students in group one following the teaching of contemporary UAV based activity.

13. The *My Class Activities* curriculum effectiveness assessment was administered to students in group two following the teaching of a contemporary UAV based activity.

14. The *My Class Activities* curriculum effectiveness assessment was administered to students in group two following the teaching of Project Lead the Way Automation and Robotics curriculum.

15. Data from the *My Class Activity* curriculum effectiveness assessment was compiled and coded for student protection.

16. Data were entered into excel, then ran through R for statistical analysis.

17. Conclusions were drawn from the analysis and review of the data.
18. Conclusions were then written and reported.

**Definition of Terms and Acronyms**

*Abstraction:* identifying general principles that create patterns

*Algorithm design:* developing the step by step process or steps for solving problems or designing solutions.

*Challenge*—as defined by the *My Class Activities* instrument: “Engages the student and requires extra effort” (Gentry & Gable, 2001, p. 4).

*Choice*—as defined by the *My Class Activities* instrument: “Gives the student the right or power to select educational options and direct his/her own learning” (Gentry & Gable, 2001, p. 4).

*Computational thinking:* the problem solving process that involves the decomposition of problems, pattern recognition, abstraction, and algorithm design. Computational thinking is essential to computer science, but integral in solving complex problems across all disciplines (Google, n.d.).

*Curriculum Effectiveness Assessment:* an assessment that characterizes curriculum effectiveness through student motivation towards a curriculum.

*Decomposition:* breaking down data, processes, problems, or designs into manageable parts.

*Enjoyment*—as defined by the *My Class Activities* instrument: “Provides the student with pleasure and satisfaction” (Gentry & Gable, 2001, p. 4).

*Industry Value Added (IVA):* The value added of an industry, also referred to as
gross domestic product (GDP)-by-industry, is the contribution of a private industry or government sector to overall GDP (United States Bureau of Economic Analysis).

*Interest* – as defined by the *My Class Activities* instrument: “Reflects positive feelings, a preference for certain topics, subject areas, or activities” (Gentry & Gable, 2001, p. 4).

*Motivation:* Operationally defined by the *My Class Activities* curriculum effectiveness assessment as a combination of interest, challenge, choice, and enjoyment (Gentry & Gable, 2001, p. 4).

*Pattern Recognition:* observing patterns, trends, and regularities in data, processes, problems and designs.

*STEM:* Science, Technology, Engineering, and Mathematics

*Traditional STEM activity:* Activities that have been employed by teachers who teach integrative STEM lessons regularly. These lessons include but are not limited to: bridge building, robotics, programming, and 3D design.

*UAV:* Unmanned Aerial vehicle
CHAPTER II

REVIEW OF LITERATURE

Introduction

The purpose of this study was to compare two different computational thinking based STEM curricula using student motivation as defined by the *My Class Activities* (Gentry & Gable, 2001) as a measure of curriculum effectiveness to motivate students. Specifically, this study compared Project Lead the Way automation based curricular activities and a recently developed activity utilizing quadcopters. This review of literature reviews computational thinking, motivational theories, the *My Class Activities* curriculum effectiveness assessment, Project Lead the Way curriculum, drone curriculum, and similar studies.

Computational Thinking

The term computational thinking was first coined in 1980 by Seymour Papert (1980), though it was not until 2006 that many people were aware of its potential ramifications. Jeannette Wing (2006) was one of the first scholars to bring to light the 21st century implications and reaches of computational thinking. In her seminal paper, Wing argued that computational thinking is a universally applicable skill set and attitude that can be leveraged when solving complex problems in any discipline. Since then, computational thinking has become the focus of research and several curricular reforms. Organizations such as Google, Code.org, International Society for Technology in
Education (ISTE), International Technology and Engineering Educators Association (ITEEA), K12 Computer Science, are all working to integrate computational thinking in all levels of education (Code.org, n.d.; Google, n.d.; ITEEA, n.d.; Sykora, 2014).

Classically rooted in computer science, computational thinking was once known as algorithmic thinking in the 1950s and 1960s (Denning, 2009). Presently, computational thinking can be defined a number of ways. The International Society for Technology in Education and the Computer Science teachers Association defines computational thinking as a process that includes but is not limited to: (1) logically organizing and analyzing data, (2) representing data through abstractions such as models, (3) automating solutions though algorithmic thinking as a series of ordered steps, (4) identifying, analyzing, and (5) implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources, and generalizing and transferring this problem solving process to a wide variety of problems (International Society for Technology in Education, & Computer Science Teachers Association [ISTE & CSTA], 2011). Googles online course, Exploring Computational Thinking, targeted at helping educators integrate computational thinking in their classroom, defines computational thinking as a problem solving process that is essential for all computer applications, but can be used in support of solving problems across all disciplines (Google, n.d.). Borrowing some of Wing’s (2006) philosophies, Google (n.d.) considers problem decomposition, pattern recognition, abstraction, and algorithm design as essential elements of computational thinking. Harvard’s research group focusing on the programming environment called Scratch has defined computational thinking around
three key dimensions: computational concepts, computational practices, and computational perspectives (Harvard, n.d.). Each one of the three dimensions can be further broken down into a number of smaller concepts and descriptions. Generally, definitions of computational thinking all share several commonalities: computational thinking is a thought process, computational thinking is independent from the discipline of computer science, and is applicable across many disciplines (Einhorn, 2012; Voogt, Fisser, Good, Mishra, & Yadav, 2015; Wing, 2006; Yadav, Mayfield, Zhou, Hambrusch, & Korb, 2014).

Computational thinking has been deemed an essential component to 21st century literacy as computational thinking has the potential to advance students problem solving abilities significantly (Williams, 2015; Yadav et al., 2014). Curricular frameworks such as the Advanced Placement course, Computer Science Principles, developed by the College Board, incorporates computational thinking (College Board, 2017). As additional research is conducted on computational thinking, a clearer picture of what is and is not computational thinking will emerge.

**Motivational Theories**

To be motivated is to be moved to do something, thus a person who is motivated acts with great energy and excitement towards completing a task. On that same note, one who is not motivated lacks impetus or inspiration to complete tasks. In the educational setting, student motivation is key to engaging students in meaningful learning activities. Students who are motivated tend to focus on, engage with, and enjoy learning more than
their counterparts (Gentry & Gable, 2001). Teachers often describe classrooms where student and teacher motivation is high, as enthusiastic, as if there is no task that seems too hard or too boring (McInerney, 2005, p. 2). This can lead to students increasing retention of course material, heightened interest in a subject matter, and overall improvements in the process of learning (Lepper & Cordova, 1992, p. 203). Due to the influences on social, cognitive, and biological regulation, motivation has been central and perennial in educational and psychological research. (Ryan & Deci, 2000a).

Two critical distinctions that can be made in motivation are between intrinsic and extrinsic motivation. Intrinsic motivation is based upon what one internally finds interesting or enjoyable. This natural type of motivation is completely separate from outside pressures or rewards and is critical to cognitive, social, and physical development (Ryan & Deci, 2000b). Typically, students who are intrinsically motivated exhibit interest and enjoyment towards a learning activity (Lepper & Cordova, 1992). Extrinsic motivation is based upon what externally encourages one to perform a task. This means that one who is extrinsically motivated will complete a task for its instrumental value, which can be defined as a means to an end, such as a grade in a class, rather than enjoyment. In the educational setting, this is classically student grades.

Self Determination Theory is a broad motivational theory that distinguishes between autonomous and controlled motivations (Gagné & Deci, 2005). Acting with autonomy can be defined as acting with a full sense of choice, whereas being controlled involves external factors contributing to a behavior (Deci & Chandler, 1986). Autonomous motivation encompasses intrinsic motivation and internalized extrinsic
motivation whereas controlled motivations encompass regulation by extrinsic factors. Self Determination Theory also states that there are three basic psychological needs that must be met for people to be autonomously motivated: competence, relatedness, and autonomy (Eriksson, 2014, p. 5755). Autonomous motivation tends to yield greater psychological health along with more effective performance on heuristic types of tasks (Deci & Ryan, 2008).

The theory of Existence, Relatedness, and Growth, commonly known as ERG, is another motivational theory stemming from Maslow’s Hierarchy of Needs that is focused around understanding factors that influence human behavior. This theory states that humankind is motivated by three groups of core needs: existence, relatedness, and growth needs. Existence needs include basic safety and physiological needs required for survival. Relatedness needs refers to humans needing to maintain important interpersonal relationships and include people’s needs for social acceptance, belongingness, and status desire. Finally, growth needs represent humankind’s desire for personal development, self-fulfillment, and self-actualization (Arnolds & Boshoff, 2002, p. 698).

**Motivational Design Models for Learning**

Due to the intricacies and implications of motivation, it is important to design curriculum in a manner that captivates student’s attention. There are three main groups of motivational instructional design: person centered, environmentally centered, and interaction centered. Person centered models postulate that people have an internal drive that influence personal development and motivation (Keller, 2010a, p. 5).
Environmentally centered models assume that behavior can be explained in the terms of an organism’s response to environment influences (Keller, 2010b, p. 31). This model relies on behavior modification through contingency management plans. Those who subscribe to this design model define motivation as the extent to which certain stimulus objects or events effect the occurrence or nonoccurrence of a behavior (Sloane & Jackson, 1974, p. 5).

Interaction centered models assume that neither the person nor the environment can explain human motivation. Instead, this model, which has also been called the expectancy-value theory, explains human values and abilities as they influence and are influenced by environmental circumstances (Keller, 2010a, p. 33). Expectancy value theory states that expectancies and values directly influence achievement, effort, and persistence. This means that task specific beliefs such as ability, perceived difficulty, and individual goals, influence expectancies and values. These beliefs are also in turn influenced by individual perceptions of their own experiences and other socialization influences (Wigfield & Eccles, 2000, p. 69). Simply put, if a student values a certain task, and has the expectancy that they can be successful at completing this task, expectancy – value theory states that this will be a highly motivated student.

**Student-Teacher Relationship Effect on Motivation**

Teacher-student relationships are arguably one of the most important influencers on how a child perceives classroom learning activities. There is strong empirical support for a reciprocal relationship between teachers' behavior and students' engagement. To that
end, as a teachers’ attitudes toward a particular subject became more positive, so did the students (Skinner & Belmont 1993). Furthering the notion of the importance of the student-teacher relationship, Krane, Ness, Holter-Sorensen, Karlsson, and Binder (2017) found that when teachers promote a friendly, caring and helpful educational atmosphere, it is likely that students will develop positive teacher-student relationship and they will thrive at school. To that end, Yunus, Osman, and Ishak (2011) found that factors such as academic achievement and student motivation are influenced by the quality of the relationship that the students and teachers have with each other.

Assessing Motivation

Due to the important role motivation plays in social, biological, and cognitive regulation, modes of assessing motivation have been extensively researched. As motivation is complex and multifaceted, researchers often pick a couple facets of interest to study. For instance, if one wishes to assess motivation through a direct means, physical and observable measures such as task performance, task choice, and task completion speed, may be of interest. (Touré-Tillery & Fishbach, 2014, p. 332). Because motivation is an internal process, it is not entirely discernable through direct observation alone. This means that in order to generate a complete picture of motivation exhibited by students, tools such as self-reporting indices, questionnaires, and surveys are used (Dörnyei & Ushioda, 2011, p. 197). These self-reporting instruments are used to capture judgements and statements about individuals own perceptions and often are easier to implement when compared to direct observations (Schunk, Pintrich, & Meece, 2008, p. 13). Robust self-
reporting instruments are often developed and validated with distinct focus on particular motivational constructs. For instance, the *My Class Activities* curriculum effectiveness assessment has been validated and applied to inform educators on student perceptions of motivation though the constructs of task interest, challenge, choice, and enjoyment (Gentry & Gable, 2001).

**Self-Reporting Motivation Curriculum Effectiveness Assessments**

Many researchers gravitate to implementing self-reporting curriculum effectiveness assessments when assessing motivation due to the ease associated with survey administration. Self-reporting style curriculum effectiveness assessments eliminate the need for costly interviewing and observing. Typically, self-reporting based curriculum effectiveness assessments have examinees respond to targeted questions based on a Likert style scale (Zaharias, 2006). These scales are often targeted at specific age groups, constructs, and outcomes. This has resulted in the development of a wide variety of curriculum effectiveness assessments targeted at audiences ranging from e-learning environments (Zaharias, 2006) to junior high level science courses (Tuan, Chin, & Shieh, 2005). As researchers vet various measurement tools used to assess motivation, a wide list of criteria should be considered. Criteria such as cost, accessibility, validity, reliability, and targeted age range should all be weighed when considering curriculum effectiveness assessments (Bylsma, 2013).
My Class Activities Curriculum Effectiveness Assessment

Gentry and Gable (2001) created a self-reporting style curriculum effectiveness assessment called *My Class Activities* to measure four central dimensions of motivation: interest, challenge, choice, and enjoyment. These four constructs of motivation are intrinsic in nature and thus very powerful in keeping students engaged. Their goal was to create an instrument that had the ability to inform teachers, administrators, and researchers on how students perceived classroom activities (Gentry & Gable, 2001, p. 1). This instrument was developed and validated to assess student’s perceptions of classroom activities by assessing the frequency in which elementary and middle school students perceive four of the crucial motivational constructs. Each construct of motivation assessed by the *My Class Activities* is defined as follows:

- **Interest:** “Reflects positive feelings, a preference for certain topics, subject areas, or activities” (Gentry & Gable, 2001, P. 4).
- **Challenge:** “Engages the student and requires extra effort” (Gentry & Gable, 2001, p. 4).
- **Choice:** “Gives the student the right or power to select educational options and direct his/her own learning” (Gentry & Gable, 2001, p. 4).
- **Enjoyment:** “Provides the student with pleasure and satisfaction” (Gentry & Gable, 2001, p. 4)

The curriculum effectiveness assessment has 31 questions with the first eight measuring attitudes towards interest, items nine through 17 measuring challenge, 18 through 24 measuring choice and items 25 through 31 measuring enjoyment. Students respond to each assessment item on a five point Likert scale (see Appendix B).
Interest

Research on student interest as it relates to achievement date back to 1913 when John Dewey began studying interest and effort (Dewey, 1913). Dewey suggested that students were much more inclined to complete a task if they were interested in what they were doing. Recent studies indicate that student motivation to work on projects is much greater if students have some type of initial interest in the subject (Patall, 2013). As such, student interest seen as a critical component motivation (Weber, Martin, & Patterson, 2001). In addition to being a motivational construct, interest in a subject helps learners develop deeper comprehension, leads to greater uses of imagery, and stimulates a more personal and extensive network of associations invoked by prior knowledge (Tobias, 1994).

Challenge

People are motivated by tasks that provide optimum challenge, more specifically, tasks that are neither too difficult nor easy to complete. As challenge within a task increases, motivation increases until it reaches a point of optimal challenge. At this point, the task that the student has been asked to accomplish is slightly beyond their perceived ability level (Deci & Chandler, 1986, p. 590). A task that extends a student much outside this point becomes overly challenging and motivation diminishes quickly. When tasks are not at the appropriate rigor level or are not engaging enough, students tend to get bored or frustrated and disengage (Chval & Davis, 2008).
Choice

As a method of motivating students in the classroom, students are often provided with choice between various learning activities to demonstrate competency. Offering students choice has been linked to increasing situational awareness, classroom engagement, and perceived competency (Schraw, Flowerday, & Lehman, 2001). Through providing students some autonomy in a learning exercise, teachers play into student’s intrinsic motivation. This plays into one of the innate psychological needs outlined by self-determination theory by fulfilling students need for autonomy (Deci, 1992). Research has also shown that by giving students choice in learning activities, teachers play to students’ internal motivator thus increasing classroom performance and motivation (Patall, Cooper, & Wynn, 2010).

Enjoyment

Enjoyment being an internal feeling, can be characterized as an internal motivator. Tasks that are enjoyable to someone are likely to be continued regardless of any outside influences. As such, enjoyment is a natural and powerful motivator (Ryan & Deci, 2000b). Enjoyment in learning tasks can influence whether or not students pursue further educational or labor market opportunities (Organisation for Economic Co-operation and Development [OECD], 2004, p. 116). Studies have shown that as enjoyment in a particular subject or learning activity increases, so does student learning (Mohammad-Davoudi & Parpouchi, 2016).
Instrument Validity and Reliability

When Gentry and Gable investigated this instrument for validity, a Tucker-Lewis goodness of fit index of .88 and mean root square of .09 was found suggesting that the constructs measured by the My Class Activities were supported (Gentry & Gable, 2001, p. 23). The Tucker-Lewis goodness of fit test confirmed that the My Class Activities assessed student motivation. Furthermore, they report item analysis and alpha internal consistency coefficients for grades 6-8 estimates the sub score from .75 to .92 with stable internal consistency across grade level data (Gentry & Gable, 2001, p. 28). During a test-retest analysis, reliability coefficients ranging from .66 to .74 were found suggesting that the assessment demonstrated adequate stability of responses (Gentry & Gable, 2001, p. 31). Nunnally (1978) recommends a reliability coefficient of .70 or higher for basic research.

Similar Studies

The My Class Activities curriculum effectiveness assessment has been extensively implemented since its development in 2000. Researchers have used this instrument to assess out-of-school enrichment activities, identify classroom activity interpretational differences between rural and suburban students, and to determine perceptional differences in classroom activities between student gender and grade level (Chae & Gentry, 2011; Gentry, Gable, & Rizza, 2002; Gentry, Gable, & Springer, 2000; Gentry, Rizza, & Gable, 2001; Gentry, Rizza, & Owen, 2002; Gentry & Owen, 2004; Pereira, Bakhiet, Gentry, Balhmar, & Hakami, 2017; Pereira, Peters, & Gentry, 2010).
In a study leveraging the *My Class Activities* curriculum effectiveness assessment, Gentry et al. (2001) found that gifted students in rural schools perceive less challenge, interest, and in some cases, enjoyment, than their peers in suburban or urban schools leading to recommendations of modifying school programming to better fit the needs of gifted students. In an effort to identify perceptual differences of classroom activities between grade level and gender (Gentry, Gable, & Rizza, 2002) leveraged the *My Class Activities* curriculum effectiveness assessment to assess a sample of 3,744 students. They found that there was a medium effect size \( R^2 = .14 \) on grade level difference, and a small effect size \( R^2 = .14 \) regarding gender in student’s perception of classroom activities. Additionally, through a study conducted on Saturday enrichment programs, the *My Class Activities* curriculum effectiveness assessment was validated for use in evaluation of out-of-school programs (Pereira et al., 2010). International variants of the *My Class Activities* curriculum effectiveness assessment have been tested and found to provide useful information for teachers and researchers provided that items that may have issues with translation are dropped from the instrument (Pereira et al., 2017). In addition to academic and research studies that have been conducted using the *My Class Activities* curriculum effectiveness assessment, academic institutions such as Purdue University have leveraged the power of the assessment for program evaluation (Pereira, 2009).

### Project Lead the Way Curriculum Overview

According to the media kit available on Project Lead the Way’s website (2017a), Project Lead the Way is a nonprofit organization focused on developing a robust set of
pathways in engineering, computer science, and biomedical science. The organization started off strictly as an engineering based curriculum in 1997 targeted at high school students. Since its founding, focus has shifted towards including grades K-12 by creating a standards aligned comprehensive curriculum in additional subject areas. Currently, the curriculum is separated into five major subsections: Launch, which is targeted at grades K-5, Gateway to Technology, which is targeted at grades 6 - 8, and Engineering, Biomedical Sciences, and Computer Science all of which are targeted at grades 9 - 12 (Project Lead the Way, 2017a).

Project Lead the Ways’ Launch curriculum contains 24 interdisciplinary modules which are designed to empower students to adopt a design based mindset through compelling hands on activities in the areas of computer science, engineering, and biomedical sciences. These activities are designed to be taught interdisciplinary as each module is aligned with state and national standards such as the Next Generation Science Standards or Common Core Standards. Projects within the Launch curriculum include designing a robot, proposing methods to prevent the spread of disease, and developing a tablet game (Project Lead the Way, 2017a).

The Gateway to Technology curriculum, launched in 2000, aligns with the philosophy that middle school is a time of exploration. This curriculum contains 10 units that empower students to their own discovery. In schools that offer many Gateway units, students get to choose between four to six units as electives. Each unit is traditionally taught as a complete semester long course spanning 12 to 15 weeks. During the middle school level curriculum, students have the option to explore activities in computer
science, biomedical sciences, 3D design, architecture, and automation and robotics (Project Lead the Way, 2017a).

The high school level programs contain courses in three distinct pathways: engineering, biomedical sciences, and computer science. These pathways focus on engaging students with real-world problems, while helping students to develop critical 21st century skills such as collaboration, problem solving, communication, reasoning, and global awareness (P21 Partnership for 21st Century Learning, 2015). Courses within the high school level pathways are designed to build a strong foundation for college and career skills. Courses offered at the high school level range from aerospace engineering to environmental sustainability. Many local educational agencies offer college credit to high school students for the successful completion of classes in the high school pathways (Project Lead the Way, 2017a).

In order for a teacher to gain access to Project Lead the Way curriculum, they must first undergo an immersive professional development session where teachers explore every lesson in a given class. These professional development sessions are typically two weeks in length for a high school level engineering course and one week in length for a Gateway to technology course (Project Lead the Way, 2017a).

Currently, Project Lead the Way serves over 10,500 schools with 2.4 million students in every state and territory in the United States. Over 37,000 teachers serve in more than 12,500 Project Lead the Way programs. Approximately 60 post-secondary and research institutions, and 100 leading corporations and philanthropic organizations have partnered with Project Lead the Way programs. These partnerships include Chevron,
Lockheed Martin, the Kern Family Foundation, Autodesk, Verizon, John Deere, Toyota, and Samsung (Project Lead the Way, 2017a). For an overview of the curriculum assessed in this study, see Appendix C.

**Project Lead the Way Curricular Research**

Project Lead the Way curriculum has been extensively studied for relevance, learning outcomes, and its role in the STEM pipeline throughout its existence. When assessed for connection to standardized learning outcomes, Project Lead the Way students were found to score significantly higher in mathematics and science when compared to their peers (Bottoms & Uhn, 2007, p. 3). Students were also found to be more likely to complete four years of math, use academic skill and knowledge to complete authentic tasks, and perceive high school as important for their future (Bottoms & Uhn, 2007, p. 3). Another study corroborated these findings by finding that students in Texas were far better prepared for higher education as measured by their state mathematics assessment (Van Overschelde, 2013). Further supporting these claims, a study conducted in the state of Iowa found that 70% of Project Lead the Way students in Iowa’s 2009 graduating class immediately transitioned into college, which is twenty percent higher than non-Project Lead the Way students (Rethwisch, Starobin, Laanan, & Haynes, 2013, p. 23). Another study conducted by Rogers (2006), found that Indiana teachers felt as though Project Lead the Way curriculum is “effective” to “very effective” in developing pre-engineering competencies in high school students. In a different study, Rogers (2007) also found that principals perceived strong effects of Project Lead the Way
on the motivation, critical thinking, and enthusiasm of their students. These findings may be due to the high achieving students that Project Lead the Way attracts to their program. Most Project Lead the Way programs are classified as honors level or Advanced Placement programs and require students to demonstrate minimum competency in math and science prior to admission (Harmony School of Discovery, 2017).

**Project Lead the Way Automation and Robotics Curriculum**

In 2000, Project Lead the Way launched its Gateway to Technology program with curriculum aimed at middle schools (Grimm & Lee, 2016). This curriculum currently contains learning activities focusing on robotics, 3D modeling, coding, flight, electronics, medicine, and green architecture (Project Lead the Way, 2017b). In the Robotics and Automation course, students learn to design, build, and program robots using the VEX Robotics platform through three multi-week lessons. These lessons focus on definitions of automation and robotics, mechanical systems, and automated systems. During the course of the lesson on definitions, students learn about the positive and negative effects of automation in practical applications such as safety, comfort, and manufacturing. During the lesson on mechanical systems, students are introduced to mechanical advantage, torque, speed, force, and types of movement which are all associated with mechanical systems. Throughout this lesson, students design and build projects such as a pull toy leveraging simple machines to articulate some type of motion. During the lesson on automated systems, students learn about sensing devices, programming, and feedback loops. The capstone project in this lesson require students to build, program, and test a
scale model of a manufacturing assembly line. Students are separated into teams and required to build a station representing a single action on an assembly line. All of these stations then have to work in unison to simulate the production of a finished part. For an outline and overview of the Automation and Robotics curriculum (see Appendix C).

Unmanned Aerial Vehicles

Historically, Unmanned Aerial Vehicles (UAVs), have been associated with military use. Beginning in the 1960’s, the United States Air Force began investigating the use of powered long range drones called Fireflies in reconnaissance (Miller, 1970, p. 50). These projects ran over budget shortly after they began, thus leading to these experimental projects being shut down (Callam, 2010). The U.S.’s interest in drone research was piqued again during the 1982 war in Lebanon though the successful implementation of the reconnaissance drone, Pioneer, by the Israeli Air force (Blom, 2010, p. 72). In 1985 and 1986 the U.S. military then purchased several Pioneer drones and modified them enabling takeoff and landing from ships. These Pioneer drones were utilized in many U.S. Navy reconnaissance operations, including Operation Desert Storm, till it was retired in 2007 (Blom, 2010, p. 73). In 1999, Chief of Staff of the Army, Eric Shinseki, announced a proposal aimed at making the army more rapidly deployable though the Future Combat System (FCS), which replaced a variety of warfighting tools such as the M1 Abrams tank and the M2 Bradley with an integrated system of UAVs, unmanned ground vehicles, remote sensors, and an advanced network to manage battle space information (Blom, 2010, p. 120). Due to the utility of drones in the military,
funding has steadily supported the development of new and more sophisticated drones. In the 2017 fiscal year, the U.S. Department of Defense allocated $4.457 billion for drone research, spread between the MQ-9 Reaper, RQ-4 Global Hawk, MQ-4C Triton, MQ-8C Fire Scout, MQ-1C Gray Eagle, and various unmanned undersea and unmanned ground vehicles (Gettinger, 2016).

As advanced UAV technology becomes cheaper and more reliable, drones are becoming more common outside of the military sector (Cavoukian, 2012, p. 3). UAVs are becoming so commonplace, that companies such as Amazon claim that they will be as common as seeing traditional mail delivery trucks (Matyszczyk, 2015). In recent years, UAVs have infiltrated industries such as surveying, inspections, science, security, situational monitoring, search and rescue, cargo delivery, aerial video and photography with emerging applications in logistics, first aid, agriculture, and mining (Microdrones, n.d.).

The personal and commercial UAV market has been growing at a rapid rate with projected global market revenue increasing by 34 percent by the end of 2017. This increases the value of the private UAV market to more than six billion dollars. That same industry valuation is projected to hit 11 billion dollars by 2020. IBISWorld corroborates this through their report on the [UAV] manufacturing industry. According to this report, the UAV industry is projected to have an annualized Industry Value Added (IVA) rate of 3.8% between now and 2025, which is 1.7% more than the United States Gross Domestic Product (Longo, 2017, p. 12). Along with a growing UAV manufacturing sector, economic reports are suggesting as many as 100,000 new jobs will be added to the United
States economy by the year 2025 dealing with UAVs (Jenkins & Vasigh, 2013). Because of their versatility, UAV technology has been regarded by industry experts as the most dynamic growth sector in the aerospace industry this decade (Cavoukian, 2012, p. 3).

The popularity of personal drones is likely to increase as consumers are employing UAVs as an affordable extension of smart devices for media creation and entertainment purposes (Forni & Van Der Meulen, 2017). Unmanned Aerial vehicles are becoming more common due to the advancement of flight hardware, development of lighter materials, and affordability. UAV industry leaders, such as Parrot, also are emphasizing drones for the hobbyist and educational market. As a part of their educational push, Parrot has started to develop curriculum to be used across grade levels. This curriculum has been developed in an effort to encourage students, educators, and researchers to learn, teach, and innovate using drones while preparing the upcoming generation for the growing commercial UAV industry.

**Quadcopter Curriculum**

The contemporary quadcopter curriculum tested in this study was developed by two graduate students from Utah State University, Russ Mayo and Jordan Bartholomew (Bartholomew & Mayo, 2018). This curriculum is comprised of four units: safety, manual flight, autonomous flight, and data acquisition. During the safety unit of the quadcopter curriculum, students learn about crucial safe practices that must be adhered to when flying their drone. The manual flight unit focuses on teaching students how to manually fly their quadcopter using pitch, roll, and yaw. Students begin by flying their
drone in a simple pattern, and end with flying through an obstacle course. Autonomous flight requires students to program their quadcopter using a block based programming platform called Tynker. This unit begins with students programming their quadcopter to fly in a simple pattern and ends with them programming their quadcopter to fly through an obstacle course. During the data acquisition portion of the curriculum, students have to program their quadcopter to remotely gather data using a data acquisition system. This unit requires students to design a mounting system to affix the data acquisition package to their drone, create a program that pilots their quadcopter to remotely retrieve data, and interpret data through charts and graphs. Students have the choice to 3D model and 3D print a mounting bracket to connect the quadcopters’ data acquisition package to the drone or use the quadcopters Lego connectors and regular Legos to mount the data acquisition system. At present, there is no professional development available for teachers looking to implement this curriculum into their classroom. The repository for the quadcopter curriculum as well as the scope and sequence that was tested in this study can be found on Appendix D.

Summary

Teachers are constantly working to motivate students in their classrooms. Students who are more motivated are more likely to stay engaged during class time, while their counterparts are more likely to disrupt learning. Curricular activities can be designed to be motivating for students by integrating activities that work into student internal motivators. If a student has some choice within a task, finds a task enjoyable,
challenging, or interesting, they will demonstrate higher motivation. This in turn leads to a more effective curriculum. Computational thinking can be defined many ways and is thought to be a universally applicable skill across many disciplines. Project Lead the Way provides students with an immersive K-12 curriculum focused on engaging students through hands projects centered on developing robust 21st century skills. The quadcopter curriculum that this study examined was recently developed by graduate students at Utah State University with four crucial learning goals in mind: safety, manual control, autonomous control, and data acquisition. The automation and robotics curricular activities examined by this study are activities taught in the Project Lead the Way, Automation and Robotics course. UAV technology is becoming so wide spread that industry leaders claim that seeing UAVs in the world will be as common as seeing a mail delivery truck. The *My Class Activities* provided an affective measurement tool that was used to determine student motivation towards Project Lead the Way’s automation and robotics curriculum and a more contemporary quadcopter activity.
CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to compare two different computational thinking based STEM curricula using student motivation as defined by the *My Class Activities* (Gentry & Gable, 2001) as a measure of curriculum effectiveness to motivate students. Specifically, this study compared Project Lead the Way automation based curricular activities and a recently developed activity utilizing quadcopters. Identified in this chapter are the following: target population, sample, research design, outcomes, curriculum effectiveness assessment, and analysis of data. Both tested curricula are also explained.

Population

The population targeted for this study was every student enrolled in Project Lead the Way’s, Gateway to Technology courses in grades 7th and 8th in a suburban school district in northern Utah during the 2017-2018 school year (*N* = 732). Demographics of the school district are as follows: 49% female, 51% male, 1% African American, 1% Asian, 12% Hispanic, 3% claim multiple races, 1% Pacific Islander, 82% White, 30% low income, 13% are students with disabilities, and 2% are English language learners.
Sample

The targeted sample for this study was 194 students \((n = 194)\). The school district chosen for this study was selected out of convenience due to geographic location and willingness of the STEM coordinator to participate. Classes studied were chosen based on willingness of the instructor to participate as well as course schedule. Three teachers from three schools teaching 7th and 8th grade Gateway to Technology – Automation and Robotics courses were selected to help in the study. These three schools were located within a suburban environment. All students who participated were enrolled in the Project Lead the Way - Automation and Robotics course as this course was selected due to its propensity for computational thinking in its curriculum. Participants and their teachers thus represent a convenience sample.

Research Design

In each course selected for this study, students were taught the entirety of the contemporary quadcopter curriculum, and one major curricular activity from Project Lead the Way’s Automation and Robotics curriculum. Both the automation curriculum and the quadcopter curriculum took approximately two weeks to complete. The automation curricular activity, though different in nature, was perceived to be the same difficulty and complexity as the quadcopter activity. This was done through collaboration with the teachers participating in the research study. Teachers were shown the curriculum content and rigor, then a comparable activity within the Project Lead the Way, Automation and Robotics course was identified.
These curricula were taught in counterbalanced fashion to eliminate sequencing effects. This was done by conveniently assigning when each class received each curriculum. Some of the classes would receive automation curriculum first, while others would receive quadcopter curriculum first. The counterbalanced design was based on teacher and researcher scheduling needs and curriculum hardware availability. Care was also taken to minimize effects of this study on the participating teacher’s normal teaching schedule. All student data gathered in this study were safeguarded as per Institutional Review Boards policy. A repeated measures ANOVA, 2 x 3, was conducted with the first factor being the assessed curriculum and the second factor being which teacher delivered the curriculum.

**Curriculum Overview**

The two curriculums tested in this study were both designed to teach crucial 21st century skills, such as collaboration, communication, coding, creativity, and critical thinking. The first curriculum, previously reviewed in the review of literature (p. 29), was developed by Project Lead the Way and is centered on the topics of automation and robotics. This curriculum uses project based learning as a method of teaching its critical learning goals. Through the course of the Automation and Robotics curriculum, students learn about applications of simple and complex machines, gear ratios and how to build and program VEX EDR robots.

The second curriculum, previously reviewed in the review of literature (p. 29), was developed to introduce students to the basic principles behind safety, manual flight,
autonomous flight, and data acquisition. The UAV curriculum was separated into four units: safety, manual flight, autonomous flight, and data acquisition. Autonomous flight relied on students to program the UAV though a visual block based programming platform called Tynker. Learning activities in this curriculum range from passing a written safety exam, to programming the UAV to fly in optimized patterns collecting as much data as possible in one minute. The quadcopter curriculum is divided into four units that are each targeted at specific learning goals. Unit one in the quadcopter curriculum focuses on safety, unit two focuses on manual flight where students have to fly their quadcopter through an obstacle course, unit three focuses on autonomous flight where students use a drag and drop style programming platform called Tynker to program their quadcopter to pilot through an obstacle course, and unit four focuses on using the engineering design process to design and fabricate a mounting bracket that will mount a data acquisition package on the drones existing structure. Students then use the data acquisition package to gather temperature and light data remotely.

**Curriculum Implementation**

In order to implement the experimental curriculum, schools who have successfully implemented Project Lead the Way’s, Automation and Robotics curriculum were identified. Communication regarding the scope of the quadcopter curriculum was then established with pertinent administrators and teachers. Teachers then participated in a two-hour training, hosted by the researchers, preparing them to teach the new quadcopter curriculum. A comparable activity to the quadcopter curriculum was then
chosen from the Project Lead the Way curriculum. After this, a schedule was created outlining the order in which each teacher was to teach the two learning activities. The teacher then carried out instruction to the students according to the research schedule. Researchers administered the curriculum effectiveness assessment insuring continuity in procedures.

**Outcomes**

This study examined one major hypothesis: middle school students are more motivated as measured by the *My Class Activities* curriculum effectiveness assessment when learning with a contemporary quadcopter based activity when compared with traditional automation based activities found in Project Lead the Way.

The curriculum effectiveness assessment titled *My Class Activities* provided a valid and reliable measure of student perception of motivation while learning with each curriculum type. Students completed this 31-item assessment at the completion of each type of curriculum. Students typically took fifteen minutes to fully complete the assessment. A repeated measures ANOVA was conducted to determine which curriculum received a higher score in each construct of motivation as measured by the *My Class Activities* curriculum effectiveness assessment. The repeated measures ANOVA test also identified relationships between the factors of teacher and scores received on the *My Class Activities* assessment.
Curriculum Effectiveness Assessment

The *My Class Activities* Curriculum effectiveness assessment was developed by Marcia Gentry, Ph.D. and Robert Gable, Ed.D. to measure student’s perceptions of challenge, choice, enjoyment, and interest of classroom activities. The curriculum effectiveness assessment consists of 31 items with the first eight measuring attitudes towards interest, items nine through 17 measuring challenge, items 18 through 24 measuring choice and items 25 through 31 measuring enjoyment. Students respond to each assessment item on a five point Likert scale. Each construct of motivation measured by this instrument was identified by Gentry and Gable as broad, overarching dimensions of motivation. For the purposes of this study, each construct of motivation as defined by the *My Class Activities* curriculum effectiveness assessment was treated separately in an effort to provide the greatest amount of information about the nature of each classroom activity. The curriculum effectiveness assessment was administered in approximately 15 minutes in paper-pencil format. Upon assessment completion, student names were replaced with identification numbers in an effort to protect student confidentiality.

Data Analysis

Data were analyzed using the statistical analysis software, R. Instrument reliability was measured using Cronbach’s alpha. A repeated measures 2 x 3 ANOVA was conducted for each dimension of motivation as defined by the *My Class Activities* curriculum effectiveness assessment. The first factor in the ANOVA test was the learning activities being compared, Project Lead the Way’s Automation and Robotics curriculum...
and the newly developed quadcopter curriculum. This was done to determine how the tested curriculum significantly differed though the constructs of interest, challenge, choice, and enjoyment. The second factor in the ANOVA was the teacher delivering the curriculum. This second factor contains three levels as there are three teachers participating in this study. The repeated measures factor in the ANOVA was the curriculum as each student received both curricula. This was done in an effort to certify that significant differences in motivation was due to the curriculum itself rather than pedagogical differences.

Summary

This study examined one major hypotheses: middle school students will be more motivated when learning with a contemporary quadcopter curriculum. This was done by comparing student’s interest, choice, challenge, and enjoyment of these classroom activities using the My Class Activities curriculum effectiveness assessment against the null hypothesis that there is no motivational difference between Project Lead the Way’s, Automation and Robotics curricular activities and quadcopter based activities. Data was analyzed in this study using a repeated measures 2 x 3 ANOVA comparing between curricular activities and the teacher delivering the curriculum.
CHAPTER IV

FINDINGS

Introduction

The purpose of this study was to compare two different computational thinking-based STEM curricula using student motivation as defined by the *My Class Activities* (Gentry & Gable, 2001) as a measure of curriculum effectiveness to motivate students. Specifically, this study compared Project Lead the Way automation based curricular activities and a recently developed activity utilizing quadcopters. Interest, challenge, choice, and enjoyment were defined as the four constructs of motivation. After attrition, this study included 103 eighth grade students from five sections of Project Lead the Way’s Automation and Robotics course taught at a local school district. The five sections were taught by three different teachers in three different schools. One-hundred nine students participated in the assessment for the quadcopter curriculum while 113 students participated in the assessment for the VEX curriculum. Students without matched curriculum assessment data were removed from the data analysis due to complications towards making statistical comparisons in the counterbalanced design. This brought the matched group size to 103 students. Of the 103 matched samples, 17 were female and 86 were male.

This study examined one hypothesis, middle school students will be more motivated as measured by the *My Class Activities* curriculum effectiveness assessment when learning with a recently developed quadcopter based activity than with traditional
Project Lead the Way robotics curriculum. A copy of the 31-question *My Class Activities* curriculum effectiveness assessment can be found in Appendix B.

**Findings Relevant to Student Motivation**

The *My Class Activities* defined motivation through four constructs: interest, challenge, choice, and enjoyment. Gentry and Gable (2001) pointed out that “although the dimensions of interest, challenge, choice, and enjoyment are moderately related, when they are considered separately they provide the most information to the user about the nature of the classroom and the student perceptions” (p. 23). The My Class Activities survey instrument was used to evaluate student perception in each of these dimensions after completing each curricular activity. This instrument has demonstrated validity and reliability in these constructs.

**Interest**

Gentry and Gable (2001) defined interest as reflecting “positive feelings or preference for certain topics, subject areas, or activities” (p. 4). The first eight questions of the My Class Activities survey dealt with the dimension of interest. Students with a high score on these items would agree that class activities often tap into their own personal interests (Gentry & Gable, 2001, p. 12). These items include the following statements.

1. What I do in my class fits my interests.
2. I have an opportunity to work on things in my class that interest me.
3. What I do in my class gives me interesting and new ideas.
4. I study interesting topics in my class.
5. The teacher involves me in interesting learning activities.
6. What I learn in my class is interesting to me.
7. What I do in my class is interesting to me.
8. My class helped me explore my interests.

Table 1 shows the student responses to these first eight items along with the mean and standard deviation for each item. Table 2 shows overall mean and standard deviation for the construct of interest categorized by curriculum.

Table 1

*Frequency, Mean, and Standard Deviation for the Dimension of Interest Items 1-8*

<table>
<thead>
<tr>
<th>Curriculum</th>
<th>Never (1)</th>
<th>Seldom (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEX</td>
<td>1</td>
<td>3</td>
<td>17</td>
<td>50</td>
<td>32</td>
<td>4.05</td>
<td>.83</td>
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<td>Quadcopter</td>
<td>2</td>
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<td>20</td>
<td>49</td>
<td>29</td>
<td>3.97</td>
<td>.88</td>
</tr>
<tr>
<td>2. Stem:  I have an opportunity to work on things in my class that interest me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>26</td>
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<td>1.03</td>
</tr>
<tr>
<td>4. Stem:  I study interesting topics in class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>.95</td>
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<tr>
<td>5. Stem:  The teacher involves me in interesting learning activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>VEX</td>
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<td>18</td>
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<td>42</td>
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<td>.96</td>
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<tr>
<td>6. Stem:  What I learn in my class is interesting to me.</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>32</td>
<td>3.98</td>
<td>.91</td>
</tr>
<tr>
<td>8. Stem:  My class has helped me explore my interests.</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>.99</td>
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</table>
Table 2

Mean and Standard Deviation Interest Categorized by Curriculum

<table>
<thead>
<tr>
<th>Construct</th>
<th>VEX (n = 103)</th>
<th>Quadcopter (n = 103)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>M: 4.0, SD: 0.7</td>
<td>M: 3.9, SD: 0.7</td>
</tr>
</tbody>
</table>

A 2 x 3 repeated measures ANOVA was conducted to evaluate student perception of interest on the effects of each curriculum as well as the effects of the teacher delivering the curriculum. The repeated measures ANOVA table, Table 3, indicates that there are no main effects for the construct of interest, or the teacher delivering the curriculum, though there is a statistically significant interaction effect between the teacher and curriculum, $F(2, 94) = 6.46, p = .00235$.

**Challenge**

Questions 9-17 on the My Class Activities survey are related to the dimension of Challenge. Gentry and Gable (2001) stated, “Children show preference for tasks that are slightly beyond their abilities and that, therefore, intellectual development requires difficult tasks” (p. 2). Children with low scores in this construct would most likely find that his or her class activities lack in engagement and effort requiring work which leads to boredom in school (Gentry & Gable, 2001, p. 12). These items include the following statements:

9. The activities I do in my class are challenging.
10. I have to think to solve problems in my class.
Table 3

Repeated Measures ANOVA Table Showing the Results for the Factors of Curriculum and Teacher with Regard to the Dimension of Interest

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
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<tr>
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<td>2</td>
<td>0.23</td>
<td>6.46</td>
<td>.0024</td>
</tr>
</tbody>
</table>

11. I use challenging materials and books in my class.
12. I challenge myself by trying new things.
13. My work can make a difference.
14. I find the work in this class demanding.
15. I am challenged to do my best in class.
16. What we do in class fits my abilities.
17. This class is difficult.

Table 4 shows the student responses to these nine statements along with the mean and standard deviation for each item. A higher score indicates a higher level of challenge. Table 5 shows overall mean and standard deviation for the construct of challenge categorized by curriculum.

A 2 x 3 repeated measures ANOVA was conducted to evaluate student perception of challenge on effects of each curriculum as well as the effects of the teacher delivering the curriculum. The repeated measures ANOVA table (Table 6), indicates that there are main effects for both the teachers delivering the curriculum, $F(2, 89) = 4.00, p = .02176$ and the curriculum itself, $F(1, 87) = 9.70, p = .002194$. Tukeys HSD post hoc test confirmed a significant difference between VEX robotics curriculum and quadcopter curriculum for teacher one $t(87) = 3.535, p = .0083$ and teacher two $t(87) = 3.193, p = .0233$, indicating that VEX robotics is more challenging than the tested quadcopter curriculum.
### Table 4

*Frequency, Mean, and Standard Deviation for the Dimension of Challenge Items 9-17*

<table>
<thead>
<tr>
<th>Curriculum</th>
<th>Never (1)</th>
<th>Seldom (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
<th>Mean</th>
<th>SD</th>
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</thead>
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<tr>
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<td>10</td>
<td>3.31</td>
<td>.89</td>
</tr>
<tr>
<td>9. Stem: The activities I do in class are challenging.</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VEX</td>
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<td>35</td>
<td>49</td>
<td>4.12</td>
<td>.93</td>
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<td>33</td>
<td>35</td>
<td>3.86</td>
<td>1.06</td>
</tr>
<tr>
<td>10. Stem: I have to think to solve problems in my class.</td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>1.00</td>
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<td>1.08</td>
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<tr>
<td>11. Stem: I use challenging materials and books in my class.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>VEX</td>
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<tr>
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<td>38</td>
<td>18</td>
<td>3.54</td>
<td>1.03</td>
</tr>
<tr>
<td>13. Stem: My work can make a difference.</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>1.12</td>
</tr>
<tr>
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<td>38</td>
<td>22</td>
<td>7</td>
<td>2.88</td>
<td>1.07</td>
</tr>
<tr>
<td>14. Stem: I find the work in this class demanding.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VEX</td>
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<td>42</td>
<td>42</td>
<td>4.13</td>
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<td>15</td>
<td>39</td>
<td>42</td>
<td>4.13</td>
<td>.94</td>
</tr>
<tr>
<td>15. Stem: I am challenged to do my best in class.</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>3.87</td>
<td>.88</td>
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<tr>
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<td>4</td>
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<td>1.03</td>
</tr>
<tr>
<td>17. Stem: This class is difficult.</td>
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<td></td>
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</tr>
</tbody>
</table>

### Table 5

*Mean and Standard Deviation for Challenge Categorized by Curriculum*

<table>
<thead>
<tr>
<th>Construct</th>
<th>VEX (n = 103)</th>
<th>Quadcopter (n = 103)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Challenge</td>
<td>3.4 0.6</td>
<td>3.6 0.6</td>
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</tbody>
</table>
Table 6

*Repeated Measures ANOVA Table Showing the Results for the Factors of Curriculum and Teacher with Regard to the Dimension of Challenge*

<table>
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<th>F</th>
<th>Sig.</th>
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</thead>
<tbody>
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<td>2</td>
<td>0.17</td>
<td>4.16</td>
<td>.0189</td>
</tr>
</tbody>
</table>

**Choice**

The next seven questions, 18-24, address the dimension of Choice. Gentry and Gable (2001) stated, “Students are engaged in meaningful learning when they are involved in projects about which they care deeply and that they choose to pursue” (p. 3). These choice items are related to both curricular and instructional groupings. A low scoring student would find little opportunity to select their educational options or directing their learning in the classroom (Gentry & Gable, 2001, p. 13). These items include the following statements.

18. I can choose to work in a group.
19. I can choose to work alone.
20. When we work together, I can choose my partners.
21. I can choose my own projects.
22. When there are many jobs, I can choose the ones that suit me.
23. I can choose materials to work with in the class.
24. I can choose an audience for my product.

Table 7 shows the student responses to these nine statements along with the mean and standard deviation for each item. A higher score indicates a higher level of choice. Table 8 shows overall mean and standard deviation for the construct of choice categorized by curriculum.
Table 7

*Frequency, Mean, and Standard Deviation for the Dimension of Choice Items 18-24*

<table>
<thead>
<tr>
<th>Curriculum</th>
<th>Never (1)</th>
<th>Seldom (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. Stem: I can choose to work in a team.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>3.81</td>
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<tr>
<td>19. Stem: I can choose to work alone.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>14</td>
<td>2.88</td>
<td>1.33</td>
</tr>
<tr>
<td>20. Stem: When we work together, I can choose my partners.</td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>40</td>
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</tr>
<tr>
<td>21. Stem: I can choose my own projects.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>2</td>
<td>2.32</td>
<td>1.06</td>
</tr>
<tr>
<td>22. Stem: When there are many jobs, I can choose the ones that suit me.</td>
<td></td>
<td></td>
<td></td>
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<td>25</td>
<td>3.71</td>
<td>1.04</td>
</tr>
<tr>
<td>23. Stem: I can choose materials to work with in class.</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VEX</td>
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<td>38</td>
<td>15</td>
<td>3.39</td>
<td>1.12</td>
</tr>
<tr>
<td>24. Stem: I can choose an audience for my product.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VEX</td>
<td>19</td>
<td>21</td>
<td>27</td>
<td>28</td>
<td>6</td>
<td>2.81</td>
<td>1.20</td>
</tr>
<tr>
<td>Quadcopter</td>
<td>19</td>
<td>24</td>
<td>37</td>
<td>17</td>
<td>5</td>
<td>2.66</td>
<td>1.11</td>
</tr>
</tbody>
</table>

Table 8

*Mean and Standard Deviation for Each Construct of Motivation Categorized by Curriculum*

<table>
<thead>
<tr>
<th>Construct</th>
<th>Curriculum</th>
<th>VEX (n = 103)</th>
<th>Quadcopter (n = 103)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Choice</td>
<td>3.5</td>
<td>0.8</td>
<td>3.2</td>
</tr>
</tbody>
</table>
A 2 x 3 repeated measures ANOVA was conducted to evaluate student perception of choice on the effects of each curriculum as well as the effects of the teacher delivering the curriculum. The repeated measures ANOVA table, Table 9, indicates that there are main effects for both the teachers delivering the curriculum, $F(2, 91) = 27.10, p = < .0001$ and the curriculum itself, $F(1, 91) = 10.14, p = .00199$. Tukey’s HSD post hoc test confirmed a significant difference in student choice between VEX robotics and the tested quadcopter curriculum for teacher one, $t(9) = 5.188, p = < .0001$, and teacher two, $t(91) = 3.801, p = .0034$.

**Enjoyment**

The last seven questions, 25-31, measure the dimension of Enjoyment. This dimension is especially important because “the best learning occurs when children enjoy what they are doing” (Gentry & Gable, 2001, p. 4). A student with high scores in this construct would find class pleasing and satisfying (Gentry & Gable, 2001, p. 13). These items include the following statements.

25. I look forward to my class.
26. I have fun in my class.
27. The teacher makes learning fun.

Table 9

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>28.88</td>
<td>2</td>
<td>.53</td>
<td>27.10</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Curriculum</td>
<td>2.00</td>
<td>1</td>
<td>.20</td>
<td>10.14</td>
<td>.0020</td>
</tr>
<tr>
<td>Teacher:Curriculum</td>
<td>6.13</td>
<td>2</td>
<td>.20</td>
<td>15.54</td>
<td>&lt; .0001</td>
</tr>
</tbody>
</table>
28. I like what I do in my class.
29. I like working in a class.
30. The activities I do in my class are enjoyable.
31. I like the projects I work on in my class.

Table 10 shows the student responses to these seven statements along with the mean and standard deviation for each item. A higher score indicates a higher level of student enjoyment. Table 11 shows overall mean and standard deviation for the construct of enjoyment categorized by curriculum.

Table 10

*Frequency, Mean, and Standard Deviation for the Dimension of Enjoyment Items 25-31*

<table>
<thead>
<tr>
<th>Curriculum</th>
<th>Never (1)</th>
<th>Seldom (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>25. Stem: I look forward to my class.</td>
<td>VEX</td>
<td>2</td>
<td>4</td>
<td>17</td>
<td>29</td>
<td>51</td>
<td>4.19</td>
</tr>
<tr>
<td></td>
<td>Quadcopter</td>
<td>1</td>
<td>8</td>
<td>12</td>
<td>32</td>
<td>50</td>
<td>4.18</td>
</tr>
<tr>
<td>26. Stem: I have fun in my class.</td>
<td>VEX</td>
<td>2</td>
<td>1</td>
<td>11</td>
<td>32</td>
<td>55</td>
<td>4.36</td>
</tr>
<tr>
<td></td>
<td>Quadcopter</td>
<td>1</td>
<td>4</td>
<td>11</td>
<td>43</td>
<td>44</td>
<td>4.21</td>
</tr>
<tr>
<td>27. Stem: The teacher makes learning fun.</td>
<td>VEX</td>
<td>3</td>
<td>9</td>
<td>15</td>
<td>35</td>
<td>41</td>
<td>3.99</td>
</tr>
<tr>
<td></td>
<td>Quadcopter</td>
<td>5</td>
<td>10</td>
<td>13</td>
<td>34</td>
<td>41</td>
<td>3.93</td>
</tr>
<tr>
<td>28. Stem: I like what I do in my class.</td>
<td>VEX</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>36</td>
<td>48</td>
<td>4.22</td>
</tr>
<tr>
<td></td>
<td>Quadcopter</td>
<td>2</td>
<td>2</td>
<td>17</td>
<td>37</td>
<td>45</td>
<td>4.17</td>
</tr>
<tr>
<td>29. Stem: I like working in a class.</td>
<td>VEX</td>
<td>2</td>
<td>2</td>
<td>17</td>
<td>36</td>
<td>46</td>
<td>4.18</td>
</tr>
<tr>
<td></td>
<td>Quadcopter</td>
<td>0</td>
<td>8</td>
<td>14</td>
<td>38</td>
<td>42</td>
<td>4.12</td>
</tr>
<tr>
<td>30. Stem: The activities I do in my class are enjoyable.</td>
<td>VEX</td>
<td>2</td>
<td>1</td>
<td>11</td>
<td>46</td>
<td>43</td>
<td>4.23</td>
</tr>
<tr>
<td></td>
<td>Quadcopter</td>
<td>0</td>
<td>5</td>
<td>13</td>
<td>38</td>
<td>47</td>
<td>4.23</td>
</tr>
<tr>
<td>31. Stem: I like the projects I work on in my class.</td>
<td>VEX</td>
<td>2</td>
<td>4</td>
<td>13</td>
<td>34</td>
<td>50</td>
<td>4.22</td>
</tr>
<tr>
<td></td>
<td>Quadcopter</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>42</td>
<td>45</td>
<td>4.21</td>
</tr>
</tbody>
</table>
A 2 x 3 repeated measures ANOVA was conducted to evaluate student perception of enjoyment on the effects of each curriculum as well as the effects of the teacher delivering the curriculum. The repeated measures ANOVA table, Table 12, indicates that there is a main effect for the teachers delivering the curriculum, $F(2, 95) = 5.7331, p = .00446$. Tukey’s HSD post hoc test confirmed a significant difference in student enjoyment between VEX robotics and the tested quadcopter curriculum for teacher two, $t(95) = 3.178, p = < .0238$, and teacher three, $t(95) = 3.643, p = .0057$. According to a means plot, teacher two’s students enjoyed the VEX robotics curriculum more than the tested quadcopter curriculum, while teacher three’s students enjoyed the tested quadcopter curriculum more than the VEX robotics curriculum.

**Descriptive Statistics categorized by Teacher**

Table 13 and 14 shows the mean and standard deviation of each construct of motivation as categorized by teacher for each curriculum. Table 15 shows Cronbach’s Alpha of reliability for each construct of motivation by curriculum. For the majority of the constructs, this study found reliability to be in line with what Gentry and Gable
Table 12

Repeated Measures ANOVA Table Showing the Results for the Factors of Curriculum and Teacher with Regard to the Dimension of Enjoyment

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>10.8</td>
<td>2</td>
<td>0.95</td>
<td>5.7331</td>
<td>.00446</td>
</tr>
<tr>
<td>Curriculum</td>
<td>0.1</td>
<td>1</td>
<td>0.21</td>
<td>.6548</td>
<td>.42041</td>
</tr>
<tr>
<td>Teacher:Curriculum</td>
<td>4.9</td>
<td>2</td>
<td>0.21</td>
<td>11.5949</td>
<td>.0010</td>
</tr>
</tbody>
</table>

Table 13

Mean and Standard Deviation for each Construct of Motivation for VEX Robotics Curriculum Categorized by Teacher

<table>
<thead>
<tr>
<th>Construct</th>
<th>Teacher 1 ($n = 36$)</th>
<th>Teacher 2 ($n = 43$)</th>
<th>Teacher 3 ($n = 24$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>M = 4.1 SD = 0.7</td>
<td>M = 3.9 SD = 0.7</td>
<td>M = 3.8 SD = 0.7</td>
</tr>
<tr>
<td>Challenge</td>
<td>M = 3.9 SD = 0.5</td>
<td>M = 3.5 SD = 0.5</td>
<td>M = 3.4 SD = 0.6</td>
</tr>
<tr>
<td>Choice</td>
<td>M = 4.1 SD = 0.5</td>
<td>M = 3.4 SD = 0.7</td>
<td>M = 2.6 SD = 0.6</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>M = 4.5 SD = 0.8</td>
<td>M = 4.1 SD = 0.7</td>
<td>M = 3.8 SD = 0.9</td>
</tr>
</tbody>
</table>

Table 14

Mean and Standard Deviation for each Construct of Motivation for Quadcopter Curriculum Categorized by Teacher

<table>
<thead>
<tr>
<th>Construct</th>
<th>Teacher 1 ($n = 36$)</th>
<th>Teacher 2 ($n = 43$)</th>
<th>Teacher 3 ($n = 24$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>M = 4.1 SD = 0.6</td>
<td>M = 3.7 SD = 0.9</td>
<td>M = 4.1 SD = 0.5</td>
</tr>
<tr>
<td>Challenge</td>
<td>M = 3.5 SD = 0.6</td>
<td>M = 3.3 SD = 0.6</td>
<td>M = 3.5 SD = 0.5</td>
</tr>
<tr>
<td>Choice</td>
<td>M = 3.5 SD = 0.5</td>
<td>M = 3.0 SD = 0.7</td>
<td>M = 3.0 SD = 0.6</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>M = 4.5 SD = 0.6</td>
<td>M = 3.8 SD = 0.9</td>
<td>M = 4.3 SD = 0.5</td>
</tr>
</tbody>
</table>
Table 15

*Cronbach’s Alpha Reliability by Curriculum and Motivational Constructs*

<table>
<thead>
<tr>
<th>Construct</th>
<th>Items</th>
<th>Quadcopter</th>
<th>VEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>1-8</td>
<td>.736</td>
<td>.706</td>
</tr>
<tr>
<td>Challenge</td>
<td>9-17</td>
<td>.592</td>
<td>.557</td>
</tr>
<tr>
<td>Choice</td>
<td>18-24</td>
<td>.654</td>
<td>.788</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>25-31</td>
<td>.802</td>
<td>.812</td>
</tr>
</tbody>
</table>

(2001) found during the initial validation of the assessment. For a graphical representation of construct score by teacher, see Figures 1-4.

**Summary**

The purpose of this study was to compare two different computational thinking based STEM curricula using student motivation as defined by the *My Class Activities* (Gentry & Gable, 2001) as a measure of curriculum effectiveness to motivate students. Specifically, this study compared Project Lead the Way automation based curricular activities and a recently developed activity utilizing quadcopters. Interest, challenge, choice, and enjoyment were defined as the four constructs of motivation. After attrition, this study included 103 eighth-grade students from five sections of Project Lead the Way’s Automation and Robotics course taught at a local school district. The sample was one of convenience.

This study examined one hypothesis, middle school students will be more motivated as measured by the *My Class Activities* curriculum effectiveness assessment
Figure 1. Means plot, INTEREST by teacher.

Figure 2. Means plot, CHALLENGE by teacher.
Figure 3. Means plot, CHOICE by teacher.

Figure 4. Means plot, ENJOYMENT by teacher.
when learning with a recently developed quadcopter based activity than with traditional Project Lead the Way robotics curriculum.

An important finding to note is that the mean score in each dimension does not vary much between the curricula. However, when the mean scores are broken out by teacher, variation between curriculums seems apparent.
CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

Introduction

The purpose of this study was to compare two different computational thinking based STEM curricula using student motivation as defined by the *My Class Activities* (Gentry & Gable, 2001) as a measure of curriculum effectiveness. Specifically, this study compared Project Lead the Way automation based curricular activities and a recently developed activity utilizing quadcopters. Interest, challenge, choice, and enjoyment were defined as the four constructs of motivation. This study included 103 eighth grade students from five sections of Project Lead the Way’s Automation and Robotics course taught at a local school district. The five sections were taught by three different teachers in three different schools. Unmatched pairs data were not used, leaving the study with 103 matched pairs of data. Of the 103 matched samples, 17 were female and 86 were male.

This study examined one hypothesis, middle school students will be more motivated as measured by the *My Class Activities* curriculum effectiveness assessment when learning with a recently developed quadcopter based activity than with traditional Project Lead the Way robotics curriculum. Identified in this chapter are the following conclusions with regard to motivation and recommendations for teachers and further studies.
Conclusions Regarding Motivation

The hypothesis that was studied was that middle school students will be more motivated as measured by the *My Class Activities* curriculum effectiveness assessment when learning with a recently developed quadcopter based curriculum than with traditional Project Lead the Way robotics curriculum. The *My Class Activities* survey instrument defines motivation through four constructs: interest, challenge, choice, and enjoyment. To determine whether students were more motivated by one curriculum over the other, four separate 2 x 3 repeated measure ANOVAs were conducted. The first factor determined differences in student perception for each of the four dimensions of motivation. The second factor in the ANOVA determined differences in the teacher delivering the curriculum. This study suggests that Project Lead the Way’s Gateway to Technology Automation and Robotics curriculum was significantly more motivating than the recently developed quadcopter curriculum in two of the four constructs of motivation. Specifically, students found the Automation and Robotics curriculum more motivating within the constructs of challenge, \( p = .0015 \), and choice, \( p = .0025 \).

Conclusions Regarding Interest

According to the 2 x 3 repeated measure ANOVA that was conducted, students were significantly more interested in curriculum as an interaction of which teacher was teaching, \( p = .0025 \). This indicates that teachers have more to do with how student interest is categorized in various curricula.

The interaction may be explained by how students interact with teachers while
they deliver curriculum. Empirically, teacher three had much higher personal interest in quadcopters while teacher one and two were admittedly more focused on additional extracurricular activities such as coaching and professional growth within graduate school. Teacher three had higher scores regarding interest for the newly developed quadcopter curriculum, where teacher one and two had higher scores regarding interest for the Project Lead the Way VEX curriculum. Personal interest in a subject may influence how the quality of instruction regarding any specific topic, especially for content areas where there is no standardized testing mandating specific objectives.

**Conclusions Regarding Challenge**

According to the 2 x 3 repeated measure ANOVA that was conducted, students were significantly more challenged by the Project Lead the Way VEX robotics curriculum, $p = .0015$. Upon further comparison, Project Lead the Way has more math intensive concepts integrated throughout when compared to the recently developed quadcopter curriculum. Within each design challenge in the VEX robotics curriculum, students are presented with integrated math lessons that involve activities such as calculating ideal mechanical advantage, which may be perceived as more challenging by students.

Also significant, $p = .0328$, was the effect of teacher on student challenge. Based on teacher’s individual preference, interest, and comfort level, teachers may choose to delve deeper into one curriculum over another. With this study being the first time that teacher one and two has taught any type of quadcopter curriculum, preference may have
been to challenge students where the teachers were comfortable.

**Conclusions Regarding Choice**

According to the 2 x 3 repeated measure ANOVA that was conducted, students were given significantly more choice in the Project Lead the Way VEX robotics curriculum, $p = .0025$. Upon further comparison, Project Lead the Way has more opportunity for students to choose their learning activity. Throughout many lessons, students are provided the choice between many design briefs to choose from allowing students to delve into subtopics that fit their specific interests. This is however also based on how individual teachers structure their classroom and learning activities. The recently developed quadcopter curriculum allowed for student choice in optional student extension activities more so than in the required units. Teachers may have cut these activities due to time and facility constrains.

Also significant, $p = <.001$ was the effect of teacher on student choice. Teaching style can influence dramatically how a teacher conducts their classroom regarding instruction, student extension and remediation. A more confident teacher may provide higher academically achieving students’ choice in differentiation activities regarding a specific curriculum where a newer, less experienced teacher may struggle with providing additional instructional exercises. Also, as a teacher becomes more experienced, student buy in becomes more important, thus potentially leading to more student choice in curricular actives.
Conclusions Regarding Enjoyment

According to the 2 x 3 repeated measure ANOVA that was conducted, student enjoyment was significantly influenced by the teacher delivering the curriculum, $p = 0.0041$. This echoes much of what has been found regarding the tested curriculums and the other constructs of motivation. Based on a teacher’s interest, the way they teach can dramatically impact how a student perceives a curricular activity. If a teacher is more interested in a curricular activity they are more likely to delve deeper into the content in an engaging manner. This is seen with teacher three who in conversation admitted to preferring teaching with newer technology such as quadcopters, where the other two teachers admitted that they were more comfortable with Project Lead the Way’s VEX robotics curriculum. These empirical results match what the My Class Activates assessment found: teacher three had a higher enjoyment level for quadcopters where teacher one and two had a higher enjoyment for Project Lead the Way’s VEX robotics curriculum.

Teachers’ Background and Other Potential Confounding Factors

Teachers and the relationship teachers build with students influence how students perceive academics (Krane et al., 2017). These relationships are influenced by a number of factors such as teaching style, teacher interest, classroom management, teacher experience level, teacher-student relationships, and teacher background. All of the teachers who participated in this study came from a wide range of academic- and work-related backgrounds and were each in a different stage of their teaching career. These
confounding factors influenced the outcome of this study.

**Teacher One**

Teacher one was the only teacher involved in this study who was formally from a teacher preparation program. This teacher was also in their first year teaching at the time this study was conducted. In conversation, this teacher admittedly preferred VEX robotics due to the minimal risk to students, which may have introduced some bias into their teaching. This teacher amongst other courses, taught two sections of Project Lead the Way’s Automation and Robotics course.

**Teacher Two**

At the time of this study, teacher two was in their tenth semester teaching Project Lead the Way VEX Robotics and was split time between two schools. This teacher would spend the morning at one school, then the afternoon periods at a different school. Additionally, teacher two also was heavily involved with coaching various sports at both schools and was in their final semester of a graduate program, which would formally conclude their route to teacher licensure. After assessing teacher two’s students for the last time, teacher two admitted that they did not spend the time they should have on the quadcopter curriculum due to other obligations. Similar to teacher one, this teacher taught two sections of Project Lead the Way’s Automation and Robotics amongst other courses.

**Teacher Three**

Teacher three had completed an alternate route to teacher licensure and had obtained a level two Utah teaching certificate. This teacher had been teaching Project
Lead the Way’s VEX robotics curriculum for some time and was working to incorporate aerial robotics into their curriculum. This teacher had historically taught basic flight mechanics using smaller, nonprogrammable quadcopters. This teacher taught half of the number of Automation and Robotics students than their counterparts at the other studied schools. This discrepancy in group size may account for a more bias results. Formally, teacher three has a background and work experience in account management.

**Other Factors**

Other factors could have influenced student motivation in this study. VEX robotics is connected to an established international competition where students build and program robots to accomplish specific tasks. According to the Robotics Education website, VEX reported more than 20,000 teams with participants in all 50 United States and in 50 countries, competing in 1,700 competitions worldwide (Robotics Education Foundation, n.d.). The newly developed quadcopter curriculum is connected to a lesser known competition called ROAVcopters where students manually fly, program, and use quadcopters to acquire data (ROAVcopters, n.d.). The longer history along with the established competition element behind VEX robotics could have driven student motivation. According to Burguillo (2010), competition between students helps to motivate students by catering to diverse learning styles and individual differences.

**Recommendations for Recently Developed Quadcopter Curriculum**

This study suggests that Project Lead the Way’s, Gateway to Technology - Automation and Robotics curriculum is more motivating to students in the constructs of
challenge and choice. Changes can be made to the recently developed quadcopter curriculum to increase student motivation to bring the new curriculum to the level of the Automation and Robotics curriculum.

Recommendations Regarding Challenge

More activities explicitly integrating rigorous math and science topics within the quadcopter curriculum would allow for more challenging learning activities thus keeping the engagement of higher achieving learners. This may be done by requiring the optional activities within the quadcopter curriculum. In addition, depending on the targeted math or science standard, this could take shape by more explicitly teaching topics such as ratios, velocity, acceleration, payload or capacity in units two through four. Also within the realm of challenge, text-based programming languages could be used to program the quadcopter thus incorporating more challenging computational learning. For students who may have past experience with programming, text based languages such as Java or Python are available to program the quadcopter used in the curriculum.

Recommendations Regarding Choice

More activities explicitly integrating student choice should be added within the quadcopter curriculum. Rather than withholding activities that integrate student choice as extension activities, curricular exercises could incorporate choice within each exercise. This could be done by a number of methods from formal curricular changes to teaching techniques. The curriculum could be formally altered to structure group exercises around
student choice. Each student could pick a role from programmer to designer and work towards their specific strengths. Informally, this could also be done by the teacher during the lesson delivery.

**Recommendations for Further Study**

This study provided evidence that though the VEX curriculum seems more challenging and offers more choice to students when compared to the newly developed quadcopter curriculum, the teacher in the room delivering the curriculum is really more influential when it comes to student interest, challenge, choice, and enjoyment. Three out of the four repeated measure ANOVAs found a main effect for the teacher delivering the curriculum, while the other ANOVA found an interaction between teacher and curriculum. These results suggest that the teachers influence student motivation more than individual curriculum or curricular activity.

The results of this study has led to the following recommendations for further study. A similar study could be conducted to replicate this study with additional schools over a larger geographical area. This could assist in determining the generalizability and reliability of the results of this study. If similar studies are able to implement a curriculum assessment in a general education class where more females are present, researchers may be able to parse out how females are motivated by various curricular activities. This could help design curriculum to attract more females to areas such as Science, Technology, Engineering, and Math (STEM) that historically are more male dominated.

Future studies regarding curricular motivation in students should also consider
the impact of teachers on student learning. Researchers looking to compare curriculums should attempt to identify a single teacher to deliver the curriculum. Assessments should be held off till the single teacher is comfortable with both the control curriculum and test curriculum before assessing motivational differences. If more longitudinal studies are not possible, future research should include a questionnaire to identify teacher interest as well as teaching experience regarding various curricular activities. By having an interest in one curricular activity over another, teachers may inadvertently introduce bias into their students. Teachers comfort level in teaching a curriculum may also introduce implicit bias into a research study.

**Summary**

The purpose of this study was to compare two different computational thinking based STEM curricula using student motivation as defined by the *My Class Activities* (Gentry & Gable, 2001) as a measure of curriculum effectiveness. Specifically, this study compared Project Lead the Way automation based curricular activities and a recently developed activity utilizing quadcopters. Interest, challenge, choice, and enjoyment were defined as the four constructs of motivation. This study included 109 eighth grade students from five sections of Project Lead the Way’s Automation and Robotics course taught at a local school district. The five sections were separated by three different teachers in three unique schools. Unmatched data pairs were not used, leaving the study with 103 matched pairs of data.

This study suggests that Project Lead the Way’s Gateway to Technology
Automation and Robotics curriculum is significantly more motivating than the recently developed quadcopter curriculum. Specifically, students found the Automation and Robotics curriculum more motivating within the constructs of challenge, $p = .00148$, and choice, $p = .00252$. Also significant were the findings of the relationship between the teaching delivering the curriculum and student motivation. The results from each dimension of the My Class Activities assessment indicated that students are significantly more motivated, based on the teacher delivering the curriculum, rather than the curriculum itself, interest $p = .00254$, challenge $p = .03283$, choice $p = < .001$, enjoyment $p = .0041$. 
REFERENCES


Appendix A

Institutional Review Board Certificate of Exemption
From: noreply@usu.edu
Sent: Thursday, November 30, 2017 8:13 AM
To: Gary Stewardson; Cory Ortiz
Subject: Approval letter from USU IRB

Institutional Review
Board
USU Assurance: FWA#00003308
Exemption #1
Certificate of Exemption

FROM:
Melanie Domenech Rodriguez,
IRB Chair
Nicole Vouvalis, IRB
Administrator

To: Gary Stewardson, Cory Ortiz
Date: November 30, 2017
Protocol #: 8948

Title: An Experimental Comparison Of Student Motivation Between Two Computational Thinking Based Stem Activities—Vex Based Automation & Robotics, And A Quadcopter Activity

The Institutional Review Board has determined that the above-referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #1:

Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
This exemption is valid for three years from the date of this correspondence, after which the study will be closed. If the research will extend beyond three years, it is your responsibility as the Principal Investigator to notify the IRB before the study’s expiration date and submit a new application to continue the research. Research activities that continue beyond the expiration date without new certification of exempt status will be in violation of those federal guidelines which permit the exempt status.

As part of the IRB’s quality assurance procedures, this research may be randomly selected for continuing review during the three year period of exemption. If so, you will receive a request for completion of a Protocol Status Report during the month of the anniversary date of this certification.

In all cases, it is your responsibility to notify the IRB prior to making any changes to the study by submitting an Amendment/Modification request. This will document whether or not the study still meets the requirements for exempt status under federal regulations.

Upon receipt of this memo, you may begin your research. If you have questions, please call the IRB office at (435) 797-1821 or email to irb@usu.edu.

The IRB wishes you success with your research.
Appendix B

My Class Activities Curriculum Effectiveness Assessment
My Class Activities Curriculum Effectiveness Tool

Test Administration Coversheet

Name: ______________________

Grade: ______________________

Teacher: ______________________

By signing your name below, you agree to answer all of the questions in this assessment truthfully.

Student Signature: ______________________
My Class Activities

We would like to know how you feel about your class activities. Read each sentence and indicate how often this happens for you in your class by coloring in the doughnut. There are no right or wrong answers. Your answers will be kept secret. Remember to color in a doughnut for each sentence.

In the example below, the person indicated that his/her class is often enjoyable.

Example: My class is enjoyable.

1. What I do in my class fits my interests.
2. I have an opportunity to work on things in my class that interest me.
3. What I do in my class gives me interesting and new ideas.
4. I study interesting topics in my class.
5. The teacher involves me in interesting learning activities.
6. What I learn in my class is interesting to me.
7. What I do in my class is interesting.
8. My class has helped me explore my interests.
9. The activities I do in my class are challenging.
10. I have to think to solve problems in my class.

Please continue on the back
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<td>11. I use challenging materials and books in my class.</td>
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<td>12. I challenge myself by trying new things.</td>
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<td>13. My work can make a difference.</td>
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<td>14. I find the work in this class demanding.</td>
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<td>15. I am challenged to do my best in class.</td>
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<td>16. What we do in class fits my abilities.</td>
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<td>17. This class is difficult.</td>
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<td>18. I can choose to work in a group.</td>
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<td>19. I can choose to work alone.</td>
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<td>20. When we work together, I can choose my partners.</td>
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<td>21. I can choose my own projects.</td>
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<td>22. When there are many jobs, I choose the ones that suit me.</td>
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<td>23. I can choose materials to work with in the class.</td>
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<td>24. I can choose an audience for my product.</td>
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<td>25. I look forward to my class.</td>
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<td>26. I have fun in my class.</td>
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<td>27. The teacher makes learning fun.</td>
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<td>28. I like what I do in my class.</td>
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<td>29. I like working in my class.</td>
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<td>30. The activities I do in my class are enjoyable.</td>
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<td></td>
<td>31. I like the projects I work on in my class.</td>
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My Class Activities Copyright Information

The My Class Activities (MCA) instrument is currently a part of the Gifted Education Resource Center (GERI) at Perdue University. This instrument was created by Marcia Gentry and Robert Gable. Marcia Gentry is currently the GERI director at Perdue University. GERI resources are opened for use as long as credit is provided to the author as stated below in the screen capture. The succeeding images on the following pages are from the GERI website stating specific procedures for instrument use as well as the form the researcher must complete to obtain the MCA.

My Class Activities (MCA)

Based on the information contained in the review of the literature related to the importance of interest, challenge, choice, and enjoyment as constructs central to learning, the survey My Class Activities was piloted, studied, and developed as an effective means to assess students’ attitudes toward their classrooms regarding these dimensions. It is designed specifically for students in grades three through eight, and it comprises of four scales: interest, challenge, choice, and enjoyment, operationally defined as follows:

1. Interest: Reflects positive feelings, a preference for certain topics, subject areas, or activities.
2. Challenge: Engage the student and requires extra effort.
3. Choice: Gives the student the right or power to select educational options and direct his/her own learning.
4. Enjoyment: Encourages the student with pleasure and satisfaction (Gentry, Galbi & Sprangers, 2008).

Because the activities that occur in classrooms occur at different times and different rates depending on the curriculum, instruction, teacher and other variables, a Likert-type frequency-response format ranging from “never” to “always” (3 times per week, 3 or more times per week, 5 or more times per week, always) was selected to assess students’ perceptions of each dimension. Students respond to each of the 31 items by indicating how frequently they perceive it occurs in their classrooms. High degrees of student perceived interest, challenge, choice, or enjoyment in classrooms are reflected by high scores, whereas low degrees of the same are reflected by low scores. For example, an average score of 4.5 or Challenge would indicate that students perceived their class activities more than often engaging and requiring extra effort from them, whereas an average score of 10 on Enjoyment would indicate that students never found their class pleasurable or satisfying.

Although the dimensions of interest, challenge, choice, and enjoyment are moderately related, they provide more information to the user about the nature of the classroom and student perceptions when considered separately. A single total score on the survey would reflect an overall level of satisfaction with school but might be too broad to measure well.

References


Click Download to access the instrument (English, Korean, Chinese, Arabic)

Please fill the form below to download the My Class Activities (MCA).

**Institution**
Utah State University

**Country/States, others please specify**
US/Utah

**Your role**
Researcher

**Others, please specify**

**Purpose**
Research use

**Others, please specify below**

**How did you hear about our site?**
Search engines

**Others, please specify below**

**Are you willing to share your findings? If yes, please leave name and contact information.**

Name: Cory Ortiz
Contact information (email): Cory.ortiz@echs.org

Thank you for your interest in the instrument. Please check back for update!

Retrieved on 6/29/2018 from
https://purdue.ca1.qualtrics.com/jfe/form/SV_d3TFrPB7CmQLyzX
Appendix C

Project Lead the Way Curriculum Overview
**Project Lead the Way’s Automation and Robotics Course**

Project Lead the Way’s Automation and Robotics course curriculum is protected by federal copyright law which bars unauthorized distribution of content. In order to obtain viewing privileges, teachers, administrators, and researchers must attend a rigorous multiday professional development on delivering Project Lead the Way curriculum. In addition to mandating training, Project Lead the Way also assesses a yearly fee for access to their curriculum. Due to copyright law, only a brief synopsis of curricular activities is provided in this study. More information on Project Lead the Way curriculum can be obtained by contacting Project Lead the Way directly at solutioncenter@pltw.org or by going to https://www.pltw.org/automation-and-robotics-unit-outline and filling out the online form.
Appendix D

Quadcopter Curriculum Overview
**Quadcopter Curriculum**

The quadcopter curriculum used in this study was developed by Russ Mayo and Jordan Bartholomew at Utah State University as a plan ‘B’ masters project. The curriculum consists of four units: safety, manual flight, autonomous flight, and data acquisition. This curriculum leveraged the versatility and programmability of the Parrot Mambo drone. Lessons are delivered through animated video rather than PowerPoint presentation. Curriculum was finished during fall of 2017 and is freely available at https://roavcopters.usu.edu/curriculum.
Curriculum for Parrot Mini Drones  
Developed by Jordan Bartholomew and Russ Mayo  
Scope and Sequence

Unit 1: Following safety procedures
1.1 Follow mini drone safety practices - PDF | Video

Unit 2: Flying the Parrot mini drone remotely
2.1 Hover the mini drone at specified altitudes - PDF | Video
2.2 Fly the mini drone in a square pattern using pitch and roll controls - PDF | Video
2.3 Fly the mini drone in a square pattern using yaw controls - PDF | Video
2.4 Fly the mini drone through an obstacle course - PDF | Video
2.5* Design an obstacle course and fly through it remotely - PDF

Unit 3: Flying the Parrot mini drone autonomously using Tynker
3.1 Program the mini drone to fly a simple pattern PDF | Video
3.2 Program the mini drone to fly through an obstacle course PDF | Video
3.3* Design an obstacle course and fly through it autonomously

Unit 4: Collecting data autonomously
4.1 Collect data using Ardusat space board PDF | Video
4.2 Design problem (making a mount for the space board) PDF | Video
4.3 Retrieve data remotely using minidrone and space board PDF | Video
4.4* Retrieve data autonomously using minidrone and space board PDF

* Optional, for faster learners or for an extra challenge