University of Cincinnati

Date: 3/29/2018

1. Lori A Cargile, hereby submit this original work as part of the requirements for the degree of Doctor of Education in Curriculum & Instruction.

It is entitled:
The Impact of Blended Learning with Khan Academy and Projects on Motivation in a Mathematics Classroom

Student’s name: Lori A Cargile

This work and its defense approved by:

Committee chair: Marshella (Shelly) Harkness, Ph.D.

Committee member: Anna Dejarnette, Ph.D.

Committee member: Kathleen Koenig, Ph.D.
The Impact of Blended Learning with Khan Academy and Projects on Motivation in a Mathematics Classroom

A dissertation submitted to the Graduate School of the University of Cincinnati in partial fulfillment of the requirements for the degree of

Doctor of Education

In the Department of Curriculum and Instruction in the College of Education, Criminal Justice, and Human Services by

Lori A. Cargile

B.S., Spelman College, 1991
M.A.T., Emory University, 1996

Committee Chair: (Marshella) Shelly Sheats Harkness Ph.D.

Date of defense: March 29, 2018
Abstract

This study used qualitative methods to investigate the impact of blended learning with Khan Academy and Project Based Learning on student motivation and attitudes towards mathematics instruction. The perspectives of 11 students and their teacher in one geometry class of students in a high poverty urban high school were explored. The Station Rotation model of blended learning was implemented over ten class periods. The students rotated daily between three stations: teacher’s station, Khan Academy, and project station.

The major findings show the students and the teacher perceived the blended learning instructional model as providing increased opportunities for discourse, personal attention, and choice when compared to whole group instruction prior to the study. These additional opportunities positively impacted student motivations and attitudes towards mathematics instruction. Further, the students valued self-paced learning, using mathematical tools, and the novelty of the blended learning environment. All 11 students preferred the instruction they received in the teacher’s group and in the project group to the instruction they received prior to the study. Eight of the 11 students perceived Khan Academy’s built-in points and badges system as mounting evidence of their mathematical capabilities resulting in increased confidence and inspiration to continue doing mathematics. The students saw personalized discussions with their classmates and the teacher as being integral to learning mathematics. Each of the components of Ryan and Deci’s (2000) Self-Determination Theory, learner needs for feelings of competence, relatedness, and autonomy, were addressed during the study.
Dedication

My dissertation is dedicated to the many family, friends, classmates, professors, and colleagues who supported me on my doctoral journey. Thank you for believing in me.
Table of Contents

Abstract ii
Dedication iv
Table of Contents v

Chapter 1: Introduction 1
   Significance 5
   Purpose 7
   Theoretical Frameworks 8
   Summary 12

Chapter 2: A Review of Pertinent Literature 13
   Emergence of Online and Blended Learning 13
   Key Terms 14
      Blended Learning 14
      Flipped Learning 15
   The Khan Academy program 16
   Method 18
   Theoretical Frameworks 21
   Blended Learning Categories 23
      Blending with Khan Academy 23
      Blending with Other Tutorial Programs 37
      Blending with Non-Khan Academy Instructional Videos 43
      Blending in Higher Education 47
   Discussion 48
   Conclusions 53

Chapter 3: Methodology 55
   The School 56
   The Teacher 59
      Ms. Sunflower’s Teaching Style 60
      Ms. Sunflower’s Teaching Team 61
   The Curriculum 61
   Introduction of Khan Academy to Students 62
   Growth Mindset 62
   Lab Rotation Model 64
   Research Design 65
   The Students 65
   Station Rotation Model 66
      Planning 67
      Student Groups 68
      Rotations 70
Chapter 5: Discussion  
Major Findings  
  Station Rotation  
  Khan Academy Station  
  Project Station  
  Role of Discourse  
Connections to Previous Research and Literature  
Challenges  
Unexpected Findings  
Conclusions  
  Research Questions  
  Future Research and Professional Development  
Implications  
References  
Appendix A: Principal Letter  
Appendix B: Teacher Consent  
Appendix C: Parent Letter  
Appendix D: Parent Permission  
Appendix E: Youth Assent  
Appendix F: Teacher Station Procedures  
Appendix G: Circle Similarity Handout  
Appendix H: PowerPoint Slides  
Appendix I: Project  
Appendix J: Khan Academy Playlists  
Appendix K: Written Survey  
Appendix L: Interview Protocols  
Appendix M: Institutional Review Board Approval
Chapter 1: Introduction

Mathematics captured my attention long ago. Its patterns, mystery, and logic satisfied my natural curiosity. In my youth, mathematics helped me to understand how things worked in the world around me. My attraction led me to earn a bachelor’s degree in mathematics. I later decided to teach and earned a M.A.T degree and teaching licensure in 4-9 mathematics and science. Most of my 10 years as a classroom teacher were spent as a 7th – 9th grade mathematics teacher in an urban school district. I learned early in my career that many of my students despised the subject that I liked. At the beginning of each school year my school hosted an Open House for students and parents to meet their new teachers for the upcoming school year. Countless parents shared their disdain for mathematics with me. Their comments were often statements like, “I hate math and was never good at it.” The student would often follow with a comment like, “Math is my worst class; it was so boring last year.” The negative comments about mathematics unfortunately often pervaded my first conversations with parents and students.

I combated the rampant student dislike for mathematics by aspiring to make my instruction fun and meaningful. I attended nearly every professional development offered for mathematics educators and learned about the most recent instructional strategies like inquiry, cooperative learning, high level questioning, and so on. Student learning in my classroom increasingly became more active and less passive. I strived to incorporate activities and projects into each unit of instruction. The projects included real world investigations that required students to connect mathematics with the world around them. My hope was that students would gain the same zest for mathematics that I had.
Many of the projects required the students to collaborate, collect data, analyze data, design, and communicate their findings. One project that the students were fond of required them to design a city park. The students learned scale and how to work within real world constraints. Another fun project required the students to conduct surveys on their peers to learn about the typical habits, likes, and dislikes of teenagers. They learned about the measures of central tendency through the analysis of real data. I heard comments from other teachers about how my students were talking about their mathematics projects in their classes. Parents told me that their children enjoyed and looked forward to my class. The war was won I thought! But, then reality set in. A battle was perhaps won, but the war was still lost.

Parent conferences were held quarterly for several hours in the evening. Each child and his or her parent met with each teacher in the teacher’s classroom to discuss progress, grades, and, occasionally, behavior. As each set of parents met with a teacher, the waiting parents sat in chairs lined up in the hallway by the teacher’s door. After each parent meeting, I looked in the hallway to see how many parents were waiting to meet with me. It was shocking. My line usually went from my door to the next teacher’s door and sometimes past the next teacher’s door. I noticed the other mathematics teachers in my building had similarly long lines. The Algebra I teacher’s line was usually the longest of all the mathematics teachers. The lines for the other content teachers were usually less than half of the mathematics teachers’ lines. It was obvious that mathematics was the most concerning subject.

In the conferences, my students who were doing well usually expressed favor for mathematics, but sometimes the parents would ask how their children were being challenged. The students who were not doing well expressed their preference for my active teaching style but complained of not receiving the one-on-one attention they needed. Students sometimes added
that they attended my after-school tutoring sessions but did not receive help on the topic that they did not understand; they would explain that the other students at the sessions had different needs. Their individual questions remained unanswered. Sometimes a parent would ask if I could meet one-on-one with his or her child. My answer was always the same. I would explain that I already gave up lunch at least once a week to help students in small groups and stayed after school at least once a week for an hour of tutoring. My afterschool sessions usually contained anywhere from five to 30 students. Some students attended to get help on the homework that was due that week, others had questions or needed assistance on a topic that was taught in class that week, a few needed more time to work on a project, and there were always at least one or two students who had missed a class session and had come to make-up the missed work. There were rarely two students with the same need. It was a juggling act. With a load of about 100 students, I could not schedule individual tutoring sessions. The parents’ only recourse was to pay tutors for their children; most of the parents at my high poverty school could not afford such a luxury. I had little time to give students the personalized help they needed. I thought there must be a better way to serve the students. I believed that individual tutoring was the answer. Tutoring combined with my active instruction would both engage students and provide students with personalized instruction. I once procured a small army of senior high school student volunteers from a local parochial school to tutor my students after school. This helped but quickly proved to be unsustainable. One-on-one personalized tutoring was an impossibility.

Despite everything I was doing to engage students, some of my students were still not getting what they needed to be successful. Additionally, it was not feasible to use projects to teach every mathematics standard. Traditional whole class direct instruction was still necessary for teaching some basic skills and procedural knowledge, but a subset of students struggled with
the pacing of whole group instruction. When I taught ninth-grade Algebra I, about one-fourth to one-third of the students failed the course each quarter. About one-fifth of my pre-algebra students typically failed the course. Unfortunately, these failure rates were somewhat typical for mathematics courses at my school. I was dismayed at my inability to help the students with their individual learning needs but had no viable solution.

Years passed. I advanced in my career and became a teacher supervisor and then an assistant principal. As an instructional leader, I still yearned for a way to both engage students with active learning and to simultaneously meet the students’ individual learning needs. I became hopeful when I learned that one of the 5th grade teachers in my building used a new online tutorial program in her mathematics classroom. She had the students work on it about once a week. I asked her about the program. She explained how each student worked on his or her own learning path and that she could look at each student’s progress on the program’s dashboard. She also explained that the program was free, and the students with computers and Internet service could work on it at home. When visiting her classroom, I looked over a child’s shoulder to see the program; I immediately recognized it. It was Khan Academy (KA).

KA is a web-based tutorial program with instructional videos and exercise modules that has 30 million worldwide registered users (Khanacademy.org, 2016). The program is used in more than 29,000 classrooms (Taylor, 2013). I had seen it featured on the television show 60 Minutes. The story was memorable. The correspondent Dr. Sanjay Gupta claimed that KA would change when, where, and how mathematics was taught (Gupta, 2012). I wondered if his assertion was true. If so, does this change in mathematics instruction lead to changes in student attitudes towards mathematics? This dissertation study examined how instruction that was
blended with KA and Project Based Learning (PBL) impacted the attitudes and motivations of one class of ninth grade geometry students to do mathematics.

**Significance**

National and international assessments of American children’s mathematics achievement have produced unenviable results. The 2013 National Assessment of Educational Progress (NAEP), known as the “Nation’s Report Card,” showed that only 26% of 12th graders were proficient or better in mathematics (National Center for Education Statistics, 2013). The mathematics proficiency of the nation’s high school seniors has remained virtually stagnant for years (Vigdor, 2013). International assessments paint a relative picture of our students’ progress in mathematics. In 2012, the mathematics literacy scores of 15-year-olds on the Program for International Student Assessment (PISA) ranked American students as 30th among the 64 participating industrialized countries (OECD Publishing, 2014). The mathematics achievement of students in the United States was categorized as “significantly below” the average of the participating countries (OECD Publishing, 2014, p. 80).

Our high school students’ lackluster achievement on standardized assessments (OECD Publishing) preceded disproportional disinterest in choosing mathematics related majors in post-secondary education (U.S. Department of Education, 2015). America’s former success as a global leader was in part due to being a frontrunner of innovation in industry, but some people fear that our position may wane due to a failure to produce future innovations (Friedman, 2006). Science, technology, engineering, and mathematics (STEM) careers are widely regarded as the fields essential to global competitiveness (Friedman). Majoring in any of the related STEM fields requires higher levels of mathematics. Choosing to take mathematics courses beyond the algebra that is required in most states for high school graduation prepares students to pursue
post-secondary careers in mathematics related fields. Mathematics literacy is “a powerful vehicle for social access and social mobility” (Schoenfeld, 2004, p. 255). Students who take higher levels of mathematics in high school are more likely to complete bachelor’s degree programs in all fields, and mathematics achievement is correlated to future success in the job market (Rose & Betts, 2001). Students who choose to enroll in optional higher-level mathematics courses and are successful are better able to participate in the American workforce (Rose & Betts). According to the U.S. Department of Education (2015), “Only 16 percent of American high school seniors are both proficient in mathematics and interested in a STEM career.” Yet, the Bureau of Labor and Statistics (Vilorio, 2014) projects that an additional one million STEM jobs will be created between 2012 and 2022.

To fill this gap, traditional pedagogies are being challenged. Some believe that conventional instruction combined with online tutoring (blended learning) produces an opportunity to provide demanding personalized instruction (Horn & Staker, 2014). Using the Internet to support learning has quickly become an inextricable part of the landscape of education. The use of blended and fully online instruction is fast growing in K-12 instruction; it was estimated that half of all high school courses will be delivered online in 2019 (Christensen, Horn, & Johnson, 2011). The Flipped Learning Network and Sophia Learning’s 2014 survey of more than 2,000 U.S. teachers indicated that 78% of teachers had used technology to blend instruction using the flipped learning model for at least one lesson (Yarbro, McKnight, Arfstrom, & Network, 2014). The various forms of blended learning are likely here to stay.

Project Based Learning (PBL) has emerged as another recent innovative pedagogical model. The PBL model of instruction involves questions or problems driven by real-world experiences and includes collaboration, critical thinking, and communication (Solomon, 2003).
PBL also typically results in the completion of a learning artifact or product (Helle, Tynjälä, & Olkinuora, 2006). Salman (Sal) Khan, the founder of Khan Academy, said, “My hope was to make education more efficient, to help kids master basic concepts in fewer hours so that more time would be left for other kinds of learning. Learning by doing. Learning by having productive, mind-expanding fun” (Khan, 2012, p. 149-150). He proposed that PBL be used in conjunction with KA. Projects, simulations, and other higher value experiential learning activities are an integral part of Khan’s constructivist plan (Khan, 2012). There is a wide body of existing research which posits that usage of PBL in K-12 STEM classes increases student interest, attitudes, and engagement (Catapano & Gray, 2015; Fantz & Grant, 2013; Kanter & Konstantopoulos, 2010; Lou, Liu, Shih, & Tseng, 2011; Thomas, 2000; Tseng, Chang, Lou, & Chen, 2013), but there is little to no extant research on the effects of blended learning with the use of online tutorial program KA (Murphy, Gallagher, Krumm, Misslevy, & Hafter, 2014a). In fact, there is little existing empirical research on blended learning with the use of any online tutorial program in K-12 education (Means, Toyama, Murphy, Bakia, & Jones, 2010; Murphy et al., 2014b).

**Purpose**

The purpose of this qualitative research study was to determine how blended learning that included the use of KA and PBL affected student motivation to do mathematics. This study informs teachers and school leaders who seek to impact student interest in mathematics.

The research questions were:

1. How is student intrinsic motivation to do mathematics impacted by blended learning with KA and PBL?

2. What are student perceptions and attitudes towards instruction that is blended with KA and PBL?
3. How are student feelings of competence, relatedness, and autonomy impacted by blended learning with the use of KA and PBL?

4. What particular features of KA impact student motivation to do mathematics?

**Theoretical Frameworks**

Motivation has recently gained attention by educators and non-educators as evidenced by the sale of more than one million copies of Carol Dweck’s 2006 book, *Mindset* (Barshay, 2015). Dweck’s research which spans more than two decades posits that an emphasis on effort rather than performance leads to increased motivation (2006). She states that “…a focus on progress through effort creates a tendency to seek and be energized by challenge” (Dweck, 1986, p. 1041). The acceptance of the challenge to do difficult mathematics problems leads to increased mathematics achievement and motivation to do mathematics. The personal traits of challenge seeking and high-persistence are characteristics of two dichotomous theories of intelligence (Dweck, 1986; 2006; 2007). Dweck asserts that students either ascribe to the belief that intelligence is fixed and predetermined at birth or that intelligence is malleable through learning experiences (Dweck, 1986).

Students with fixed mindsets are inspired by external factors and are extrinsically motivated. These factors include the avoidance of negative judgments or the attainment of positive judgments from others. In a fixed mindset, a perceived high ability results in some challenge seeking, risk taking, and persistence, but a perceived low ability results in low persistence and the avoidance of challenge. Increased effort is viewed as an indicator of low abilities; therefore, the defensive goal is to be viewed as smart with the added appearance of exerting little effort. The goal is to perform and not necessarily to gain competence. To maintain the appearance of high ability, the children with performance goals must avoid any
challenge which may exceed their self-perceived abilities thus stifling learning (Ames, 1992; Dweck, 2006). These students may not persist in doing challenging mathematics and may not enroll in optional higher-level mathematics courses. Dweck posits that students with fixed mindsets will only accept tasks that they believe they can successfully complete. The ultimate aim is to be perceived as doing better than others (Dweck, 1986; Dweck, 2006).

Alternatively, children with a growth mindset believe that intelligence is malleable. They have learning or mastery goals. The goal of doing academic tasks is to learn. Students who ascribe to this theory seek challenges and persist in doing mathematics. Setbacks are perceived as welcomed opportunities. Risks are accepted. Concern is given to internal goals of increased competence rather than appearances to others (Dweck, 1986, 2006, 2007). The belief prevails that continued effort leads to success, and struggle is an expected component of success. Children who are oriented towards learning goals seek continuous improvement, understanding, and new competencies. Research indicates that learning and mastery goal oriented beliefs promote “long-term and high-quality involvement in learning” (Ames, 1992, p. 263). Motivation and stamina for learning are generated. Although learners may initially ascribe to a fixed mindset, a growth mindset can result from affirmations of effort, recognition of improvement, and learning about brain science (Blackwell, Trzesniewski, & Dweck, 2007).

The points, badges, and other features of KA and the blended learning environment may promote a growth mindset in students. Users of KA collect “energy points” and badges in their personal profile webpage. The accumulated energy points and badges are visible to the user and the teacher and are not prominently displayed on the computer screen when KA is being used. The KA website states, “Energy points measure effort on Khan Academy. Learners earn more energy points for pushing the edge of their knowledge. They are not a measure of mastery or
ability…Badges are awarded for behaviors – some related to points, but not necessarily” (Khanacademy.org, 2013). Some of the badge titles related to effort are: “Sticktoitness,” “Challenge Accepted,” “Good Habits,” “Persistence,” and “Picking Up Steam.” The KA student user collects a variety of virtual badges and “energy” points as a game like incentive to encourage program usage (TED2011, 2011, 17:10-17:15). The virtual badges are awarded for both the completion of tasks (effort) and for the correctness of problems (performance) whereas some instructional and gaming computer programs only award performance.

Another feature of KA that may foster student motivation is the program’s mastery notifications. The pop-up notices of topic mastery may serve as achievement markers or evidence of competence. A perception of competence to do mathematics successfully is a requirement for motivation according to educational psychologists Ryan and Deci (2000). Their self-determination theory asserts that intrinsic motivation requires the fulfillment of three psychological needs: “competence, autonomy, and relatedness” (p. 68). Environments which include challenge and positive feedback promote increased self-perceptions of competence (Ryan & Deci). The KA user immediately knows if the input answer is correct. A check appears in a box in the top right corner of the screen and a happy face appears for correct answers. If the answer is incorrect, energy points are not deducted. When the answer button link is clicked to input an incorrect answer the answer gyrates, and a button link that provides hints appears. An “x” also appears in a box on the top right of the screen. The user can, at a glance, determine the number of correct or incorrect answers that have been input in the session. The appearance of the x is the only penalty for an incorrect answer (points are not lost) thus creating a low risk environment with continuous substantive positive feedback. Social comparisons or public judgments that are standard in some school classrooms like grouping based on perceived
abilities, the posting of class assessment scores, and the announcements of top grades reduce children’s confidence increasing the avoidance of challenge (Ames, 1992). KA privately displays its points and badges system creating a non-competitive and individualized learning environment.

To create autonomy as required by Ryan and Deci (2000), the learner must believe that any positive outcomes are the results of self-directed choices, independence, and exerted output. Task easiness or luck cannot be perceived factors. Choice increases the locus of causality which is the feeling that one has caused an outcome. Teachers can allow students to make choices by letting the students choose which of an assigned list of KA exercise sets to work on, the order to work on the sets, and which achievement level to strive for on each set. Students can choose when to take “mastery challenge” assessments that allow them to reach the Mastered level on various topics without completing the exercise sets. Choice is also provided by the convenience of the online environment. Users are able to use the product anywhere with internet access. Usage is not limited to school hours or the school building.

When students do choose to work on the KA program in public the work environment is rendered judgment free because the points and badges are not prominently displayed. Privacy and security (relatedness) are maintained. This relatedness may increase a sense of community in the classroom. The KA program also provides a synchronous discussion board where users can pose and answer questions and make comments to other users around the world creating a community of learners. These increased interactions may satisfy Ryan and Deci’s (2000) relatedness requirement. KA does seemingly provide students with opportunities to achieve perceived competence, autonomy, and relatedness as required by Ryan and Deci’s Self Determination Theory.
Summary

My two decades of experience as an educator have enabled me to witness the rampant disfavor that many children have for mathematics firsthand. Through my own search for a solution, I learned that active learning, specifically PBL, improved student engagement and motivation to do mathematics. The opinion that PBL positively impacts motivation to do mathematics is supported by countless personal anecdotal information; however, projects alone do not fill learning gaps. In my observations, whole group instruction, whether active or passive, did not allow opportunities for students to learn at their own pace and on their own level. KA may be a solution to my desire to address students’ unique needs because the program provides a free platform for individualized learning.

For this qualitative study, I examined the perspectives of one teacher and her students on how the use of blended learning with PBL and KA may or may not affect student attitudes towards learning and doing mathematics. The second chapter contains a review of literature that highlights existing research and field reports on blended learning and Khan Academy. The third chapter describes the methodology used in the study. The fourth chapter discusses the findings of the study, and the fifth and final chapter explains the implications and future recommendations of this study.
Chapter 2: A Review of Pertinent Literature

“If we teach today’s students as we taught yesterday’s, we rob them of tomorrow.”

John Dewey (1966, p. 167)

Emergence of Online and Blended Learning

By 2014, almost all public school districts used online learning in some capacity (Horn & Staker, 2014). The use of online learning as a supplement to conventional instruction emerged throughout the country (Horn & Staker). An unscientific Google® search on August of 2017 using the search term “blended learning” yielded over 7 million results, and more than 87,000 results were found on Google Scholar®. These numbers increased substantially from 4.3 million and 60,000 (respectively) since March of 2015. In school year (SY) 2013-14, at least 24 states had fully blended learning schools (Watson, Pape, Gemin, & Vashaw, 2015). The Ohio Blended Learning Survey was conducted collaboratively in the spring of 2015 by the Ohio Blended Learning Network, the Learning Accelerator, and the Clayton Christensen Institute. Two hundred eleven of the state’s 994 charter schools and districts responded. Seventy percent indicated that they either were already using blended learning or had plans for implementation in the near future (Arnett et al., 2015). Blended learning has quickly become a popular and growing component of K-12 education (Horn & Staker, 2014).

A multitude of online commercial mathematics instructional products exists. Some are software programs for fully online courses that are intended to replace face-to-face instruction. These courses often serve students in non-traditional virtual high schools and students in traditional schools where higher level courses are not offered face-to-face (Horn & Staker, 2014; Watson et al., 2015). Other software programs are intended for use as supplemental learning tools. These supplements are typically used to create blended learning environments (Horn &
Khan Academy® (KA), MathXL®, Cognitive Tutor®, APEX®, TenMarks, and ALEKS® are some of the tutorial software programs used to blend K-12 mathematics instruction. Of these programs, Khan Academy is the only program that is completely free.

In 2015, KA was used by about 12 million people around the world each month (Banerjee, 2015). By the end of 2016, KA had 50 million registered users (Khan Academy, 2016). Despite the program’s use by millions, little is known about its effectiveness or how the program is used in classrooms (Murphy et al., 2014a). For this review, I surveyed research relevant to the use of KA as an educational resource for blended learning in K-12 mathematics classrooms and the resulting perceptions of both teachers and students. My goal was to determine if blended learning with KA and PBL impacted student attitudes and interest towards mathematics. Literature on PBL was not examined as it has been widely established that PBL positively impacted student interest, engagement, and attitudes (Catapano & Gray, 2015; Fantz & Grant, 2013; Kanter & Konstantopoulos, 2010; Lou et al., 2011; Thomas, 2000; Tseng et al., 2013). The intent was to use the limited extant empirical research, preliminary data, and informal research reports to inform my dissertation research.

Key Terms

**Blended learning.** The term blended learning is typically used to describe a model of classroom instruction that involves the integration of educational technology with some form of face-to-face instruction. Its definition evolved to suggest more than a mere use of technology as a complement for traditional lecture-styled instruction and now suggests a shift in the learning delivery model (Staker, Horn, & Innosight Institute, 2012). Staker and Horn (2012) defined blended learning as:
“…a formal education program in which a student learns at least in part through online
delivery of content and instruction with some element of student control over time, place,
path, and/or pace and at least in part at a supervised brick-and-mortar location away from
home” (p. 3).

Horn and Staker’s 2014 definition of blended learning added the requirement of an “integrated
learning path” where “the online and face-to-face components work together to deliver an
integrated course” (p. 35). The student progress data generated from an online technology are
used to inform face-to-face instruction creating a learning environment where the modalities of
instruction are connected (Horn & Staker). Blended learning is distinguishable from e-learning,
online learning, virtual learning and similar terms by its flexibility of when, where, and how
learning occurs (Staker et al., 2012). In a blended learning environment, online learning can
occur beyond school hours and outside of the school building, and adaptive online programs may
allow student learners to work at their own pace on individualized learning paths (Staker et al.).
Fully online school programs and online learning that is not part of a school program such as the
recreational use of KA are not examples of blended learning (Horn & Staker; Staker et al.).

In adult education, blended learning typically implies that at least some face-to-face
(colloquially referred to as seat time) instruction is replaced with the required student use of
technology (Staker et al., 2012). Most definitions of blended learning in higher education
settings require the reduction of seat time, creating an obvious major difference between blended
learning in higher education and in K-12 environments (Staker et al.).

**Flipped learning.** Flipped learning is one of several models of blended learning, but as
with blended learning, the definition has evolved over time. Technology is used to teach and/or
to reinforce basic content skills freeing up more of the teacher’s time to teach valuable cognitive
skills (Bergmann & Sams, 2012; Khan, 2012). Flipping typically involves an inversion of the traditional learning structure (Bergmann & Sams). Learning that usually occurs at school through teacher-directed lecture is replaced by the viewing of recorded instructional videos as homework (Bergmann & Sams, 2012; Staker et al., 2012). New topics are often introduced through homework. In a flipped classroom, ideally, less class time is dedicated to lecture and more time is available for higher order activities (Bergmann & Sams, 2012; Khan, 2012).

The Khan Academy® program

Salman (Sal) Khan, a former hedge fund manager, serendipitously conceived of KA after he began tutoring young relatives remotely via YouTube videos in 2006. Bill Gates, of the philanthropic Bill and Melinda Gates Foundation saw the public videos, and he, along with other philanthropists, provided the financial support to launch KA as a non-profit organization in 2010 (Khan, 2012).

KA is an adaptive online (www.khanacademy.org) tutorial program with three primary components: instructional videos, exercise sets, and a dashboard of student data. The program is considered adaptive because students can work on individualized learning pathways. Its mission is “to provide a free world-class education, for anyone, anywhere” and describes itself as a “personalized learning resource for all ages” (Khanacademy.org, 2016). To date, it includes more than 6,000 instructional videos on various topics, but most are dedicated to mathematics. The videos were initially created exclusively by Khan (Thompson, 2011) but some videos are now created by other employees at KA. Each exercise set and its aligned instructional videos are paired with a discussion board where students can ask content-related questions to other users in real-time. The most widely used component of the program is its bank of mathematics practice exercises (Bernatek, Cohen, Hanlon, & Wilka, 2012; Light & Pierson, 2014; Murphy et al.,
Users receive immediate feedback on their work. Hints and aligned instructional videos are available if students need help. Users collect badges and energy points as they participate in the program as an incentive. The performance data are collected in an organized color-coded dashboard for parents and teacher use. According to Khan, the dashboard is the most critical part of the program (Khan, 2012).

Teachers are encouraged to use the detailed student data to plan classroom opportunities for more individualized small group mastery learning. With a glance at the dashboard, a teacher can determine which students have mastered any learning objective and which students need remediation. Receiving the mastery notification for a topic requires users to consecutively answer a series of exercises correctly. Students can also receive mastery notifications for a skill by accepting and completing KA’s Mastery Challenge assessments that are periodically released by the program (not the teacher). The program also includes a “coach’s resource” module that houses best practices videos and documents for teachers, tutors, or parents. The module explains how teachers can use the student data to plan instruction and how student-centered projects and activities can be integrated into instruction.

Khan believed the practice exercises serve as a personalized and efficient mechanism for delivering foundational knowledge (Khan, 2012). A critic of KA, Schwartz (2014), asserted that KA focused on decontextualized opportunities for practicing basic mathematics skills and did not result in what he described as *authentic understanding*. Some of the KA exercises could be categorized as straightforward practice exercises while others are multi-step, interactive, and more complex. Some KA exercises include visual models. Solutions to the exercises are input in a variety of formats including open-ended type-in, multiple-choice, and exercises that require manipulation. A manipulation exercise might require a user to plot a point on a graph, transform
a figure on a graph, or to draw a geometric figure to scale on a graph. Some exercises require
more than one solution or are open-ended. For example, a user might be asked to manipulate a
rectangular array of dots to determine the number of factors of a number. The user might type in
the answers but not know how many factors or how many correct solutions exist.

In general, the program primarily focuses on lower level skills allowing the classroom
teacher to spend less time providing often mind-numbing lecture and replacing it with higher-
yield real world engaging activities that prepare learners with 21st century skills (Khan, 2012).
In a 2011 interview with online magazine edutopia (www.edutopia.org) Khan explained, “…a
teacher can finally have every kid going at their own pace and have the teacher really focus on
what we would consider kind of higher value-added activities, which is running simulations with
students, doing actual interventions, getting the students to teach each other the concept…”
(Flink, 2011, 8:00). Khan’s vision is that KA be used to facilitate personalized, engaging, and
cognitively demanding learning experiences.

Method

For this literature review I examined research conducted between January 2005 and May
of 2016 to determine the impact of blended instruction with KA to impact students’ attitudes
towards mathematics. An additional search for research published between May of 2016 and
December of 2017 was conducted at the culmination of writing this dissertation, but no studies
were found that added substantial knowledge to the review of literature. Student perceptions of
the web-based tutorial program were examined to elucidate possible effects on their attitudes.
Student achievement did not directly relate to the research questions of this review but was
examined due to its possible relationship with student and teacher attitudes and perceptions.
Student attitudes towards mathematics have at least some correlational or causal relationship
with achievement in the early grades, and a limited body of research shows that this relationship may be slightly greater for secondary students (Dumais, 2009; Ma & Kishor, 1997). At least to some degree, student achievement and attitudes towards mathematics are intertwined. For this reason, student achievement was not dismissed when discussing student attitudes about blended learning. The research questions were:

1. How is student intrinsic motivation to do mathematics impacted by blended learning with KA and PBL?
2. What are student perceptions and attitudes towards instruction that is blended with KA and PBL?
3. How are student feelings of competence, relatedness, and autonomy impacted by blended learning with the use of KA and PBL?
4. What particular features of KA impact student motivation to do mathematics?

For this review, I was severely constrained by the lack of empirical study of both KA and blended instruction in K-12 settings. Despite the prevalence of blended learning, there was a substantial gap in scholarly knowledge of the instructional strategy (Cavanaugh, Barbour, & Clark, 2009; Enyedy, 2014; Murphy et al., 2014b; O'Dwyer, Carey, & Kleiman, 2007; Yarbro et al., 2014). The gap was even greater in K-12 settings. A 2010 meta-analysis conducted by the U.S. Department of Education determined that few rigorous studies existed on the effects of blended and online learning particularly in K-12 settings (Means et al., 2010). The U.S. Department of Education’s (Means, Toyama, Murphy, & Baki, 2013) second meta-analysis on blended and online learning was comprised of 45 empirical studies (four were dissertations) but only included seven K-12 studies.
The field of research on KA is even more constrained than on blended learning. KA gained popularity in 2011 but has garnered little attention in the scholarly research community regardless of its use by millions (Murphy et al., 2014a). Most of the existing research was released in self-published reports and unpublished dissertations. International studies published in peer reviewed journals were included in the review because KA is used internationally. The discipline of mathematics is unique; therefore, only studies that were conducted on students enrolled in mathematics courses were included. Blended learning studies were included if the instructional technology was similar to KA. The technology was required to be adaptive, assistive, or a personalized tutorial program. Non-tutorial instructional technologies and e-learning tools (ex. GeoGebra) that did not provide students with immediate feedback, individualized learning pathways, and progress information were excluded. Studies that only analyzed achievement were included for the aforementioned reasons but were not reviewed in depth as the research questions for this review focused on impacts on student perceptions and attitudes.

Additionally, much of the limited body of research was conducted in post-secondary educational settings. It is widely asserted that adults learn differently than children (Cavanaugh et al., 2009) but to broaden the review, studies set in higher education were included if the course was a required undergraduate mathematics course for non-mathematics or STEM field undergraduate majors. Students who elect to major in STEM fields may have pre-existing positive dispositions towards mathematics. Influences on their attitudes and perspectives towards mathematics may differ significantly from the general population. Additionally, factors that affect graduate students’ attitudes towards mathematics might also differ significantly from
those of K-12 children. To widen the body of analyzed research, dissertations, self-published studies, and quasi-experiments (studies without randomized controls) were also included.

Summons, ERC, ERIC, EDitLIB, ProQuest Dissertation and Theses, and PsychInfo databases were searched. The search terms included: *Khan Academy*, *flip*, *blend*, *hybrid instruction* and *learning*, *secondary*, *elementary*, *middle*, and *junior high school*. The search yielded 19 studies.

**Theoretical Frameworks**

In this review of literature on the nascent topics KA and blended learning, several theoretical frameworks emerged. Few of the surveyed articles included traditionally identified frameworks, but I was able to presume some of the theories that may have been used to structure the studies.

Constructivist theory was cited by Pane (2014) and Clark (2013). The theory asserted that student learning was the result of “internally constructed understandings of how their worlds function through questioning, continuously revising their understandings, conducting research, and through activities that fostered and challenged their natural inquisitiveness” (Brooks & Brooks, 1999, p. viii). Deep conceptual understanding was the result of instruction which focused on “big ideas” where students investigated their suppositions and built upon prior understandings (Brooks & Brooks).

Light and Pierson (2014) used Vygotsky’s socio-cultural theory to ground their study. The theory asserted that students grew cognitively through social interactions with each other and with their teacher (Vygotsky, 1980). The researchers used observation and teacher interviews to assess the depth of students’ mathematical conversations before and after blended learning with KA. Although none of the other reviewed articles directly mentioned Vygotsky’s...
theory, student collaboration and teacher questioning were examined in at least 12 studies (Bernatek et al., 2012; Clark, 2013; Muir, 2014; Murphy et al., 2014a; Murphy et al., 2014b; O'Dwyer et al., 2007; Pane et al., 2014; Rand Corporation, 2014; Wiginton, 2013; Wilson, 2013; Yarbro et al., 2014; Yushau, 2006). Data regarding student and teacher interactions were collected through observations and surveys.

Bandura’s theory of social cognitive theory was cited in one surveyed article. Wiginton (2013) referenced Bandura’s theory to explain students’ need to feel confident in their abilities to do mathematics. Mathematics self-efficacy is required for learners to persist in solving exercises or in completing tasks. The attainment of goals results in increased self-efficacy (Bandura, 1977). Again, only Wiginton directly used social cognitive theory to ground his study, but at least two of the reviewed studies analyzed self-efficacy outcomes (Light & Pierson, 2014; Murphy et al., 2014a). Light and Pierson (2014) detected that self-efficacy improved as a result of KA’s point and badges system. Some students perceived their points and badges to be evidence of their mathematical competencies and abilities.

The third prominently emerging theory was Zimmerman’s self-regulatory theory. The theory posits that engagement and motivation result from the students’ abilities to control their learning environment. Learning that is self-paced and individualized enables students to set goals, self-assess, organize, and plan (Zimmerman, 1990). Again, only Light and Pierson (2013) directly mentioned self-regulatory theory, but self-regulation was discussed in several additional surveyed studies (Murphy et al., 2014a; Pane, Steiner, Baird, & Hamilton, 2015; Straw, Quinlan, Harland, & Walker, 2015; Wiginton, 2013). Nearly all of the studies that examined non-achievement outcomes gave a cursory mention to students’ abilities to control their learning environment while using KA.
A theory that did not emerge during this review was Ryan and Deci’s Self-Determination Theory (SDT). The theory asserts that students persist at tasks which satisfy their needs for competence, relatedness, and autonomy (2000). Several studies mentioned that students felt an increased sense of competence to do mathematics as they reached perceived achievement markers such as the accumulation of points and badges and the mastery of topics (Light & Pierson, 2014; Murphy et al., 2014a). Students also reported a sense of autonomy as they were able to control their learning environment (Bernatek et al., 2012; Light & Pierson, 2014; Murphy et al., 2014a; Project Tomorrow and The Flipped Learning Network, 2015; Roshan & Roshan, 2014; Wiginton, 2013; Yushau, 2006). The relatedness, or social connectedness, may have occurred as student-to-student interactions were increased. Although this theory was not explicitly explored in any of the reviewed articles, I inferred that the researchers believed SDT or at least some components of SDT to have an impact on students’ motivations and attitudes towards mathematics because data were dominated by observations of student autonomy, relatedness, and feelings of competence.

**Blended Learning Categories**

Within this review of pertinent research on Khan Academy and blended learning, several categories surfaced. The topics were divided into categories by the features of the studied online programs and the age level of the participants. The categories were: blended learning with Khan Academy; blended learning with programs that were similar to KA; blended learning with the use of instructional videos but without the use of exercise sets; and, relevant blended learning in higher education.

**Blending with Khan Academy.** To date, the largest study of KA was conducted by the non-profit SRI International Center for Technology in Learning and was released in March of
2014. The 82 page unpublished report, *Research on the Use of Khan Academy in Schools*, documented how KA was used as an instructional tool and its impact on both achievement and non-achievement outcomes in a pilot study of nine California schools. The first year of the study (SY 2011-12) included seven school sites with 55 participating teachers and 1,694 students. The second year (SY 2012-13) of the study included 63 participating teachers and 2,246 students in nine school sites. The structures and management of the participating schools varied greatly. Public, independent, and charter schools were included. The majority of the sites served high-poverty students, but Site 1 served a very affluent community. For this reason, the researchers disaggregated Site 1 in most analyses. Additionally, Site 1 included the most participants (n ≈ 1,000) and began using KA before most of the other participating districts giving them more experience with the program. Data were collected through student and teacher surveys and interviews, KA usage statistics, and through observations made during site visits. Many of the sites received in-person implementation support from KA personnel.

KA was used in a plethora of ways as a supplement to traditional teacher led instruction in the participating schools. Only about 20% of teachers reported assigning KA for homework at least once a week, and only about 20% of teachers used KA to introduce new topics. Most teachers used KA to provide practice and reinforcement for previously taught skills; few used KA to facilitate flipped learning. The amount of time spent using KA varied tremendously. Some teachers required students to use KA as a primary instructional tool for up to 45 or 60 minutes each day while others only suggested that students use KA as a personal tutor when needed, as determined by the student. Site 1 had a low usage of 11 minutes per week in SY 2012-13 in comparison to Site 2’s high usage of 90 minutes per week. More than 85% of overall usage time was spent doing the exercise sets (p. viii). The students spent little time watching the
instructional videos. The researchers observed that the students only accessed the instructional videos when no other assistance was available. More than half of teachers reviewed the student dashboard at least weekly and used the data to plan small group instruction to be led while the majority of the class worked on KA (p. 28). Some teachers used the Station Rotation model of blended learning where the students rotated between working with the teacher in a small group and working on KA, and sometimes the rotations included a third activity or practice work station.

Overall, the study shined a positive light on KA as a tool for blended instruction. The surveys and interviews indicated teacher favor for the program. More than three quarters of teachers believed KA had a positive impact on students’ procedural skills, believed it increased conceptual understanding, said KA helped students to learn beyond their grade level, and believed KA facilitated self-paced learning. Most teachers also believed that KA enabled students to own and regulate their own learning. Both the teachers and students reported that the immediate feedback and progress reports provided by KA made students more aware of their progress and immediately supported students in correcting any mistakes. Students had a greater understanding of their strengths and weaknesses and could modify their learning behavior accordingly. Some teachers indicated that this awareness prompted the students to ask more questions and engage in more academic discussions with the teacher and their classmates. These teachers believed that using KA inspired students to create informal learning communities.

Although teacher perceptions were generally positive, it is worth noting Site 1’s teachers were significantly less favorable of KA’s impact on student motivation to learn mathematics. Thirty-five percent of the teachers in Sites 2-9 felt that KA had a strong impact on motivation to learn mathematics in comparison to only 18% of Site 1’s teachers (p. 34). The researchers did
not attempt to presume causes of the disparity, but it is possible that the teachers’ in Site 1’s pre-existing opinions of their students’ motivation to learn mathematics may have been higher than in the other sites perhaps due to the site’s high economic status. If the Site 1 teachers believed their students were motivated to learn mathematics before the introduction of blended learning with KA, they might have perceived the program to be less impactful. It would have been useful if the researchers had also surveyed the teachers’ pre-perceptions of student motivations to learn mathematics rather than only the post-perceptions.

The Research on the Use of Khan Academy in Schools study’s data included two student surveys that were given pre- and post in the fall and spring of SY 2012-13. The anxiety, self-concept, and interest scale was developed for the widely recognized Programme of International Student Assessment (PISA) (Ferla, Valcke, & Cai, 2009). The efficacy scale was Patterns of Adaptive Learning Study (PALS) which assessed the students’ perceptions of their abilities to do mathematics (Midgley et al., 2000). Nearly one-third of students reported on the post-survey that they liked mathematics more, almost half reported being able to learn things on their own, and nearly three-quarters reported that they enjoyed using KA. Fifty-six percent of the grade 5-8 students indicated that the points and badges system motivated them to work harder (although this number was significantly lower (28%) for the high school students) (p. 32). Over 40% of students reported that KA helped them to gain a better understanding of mathematics and helped them to learn independently (p. 36). About one third of students reported having increased confidence in their abilities to do mathematics. Anxiety was shown to have an inverse relationship with the number of completed exercise sets. The students who completed more exercise sets had greater confidence in their abilities to do mathematics. Site 1 (n ≈ 1000) was the only site that participated in the student surveys. Again, Site 1 was described as very affluent
and the district had the lowest usage rate in the second year of the study. Sites which required greater usage of the program or had more student diversity may have had different survey results.

When analyzing achievement, the researchers used the fall student scores for sites 1 & 9 on the state mandated California Standards Test (CST) to predict the spring scores. Positive correlations were shown between the amount of time and the number of completed KA exercise sets with achievement; however, the trends were not statistically significant for some grade levels due to the limited sample sizes. Further complicating the potential correlation of the analyses was the interwoven nature of the usage of KA and teacher led instruction. The varying impacts of different teachers’ instruction cannot be separated from the impact of KA on student achievement. The majority of the correlational achievement results were from Site 1. Once more, the results might have been different if students with a variety of socioeconomic statuses had been tested or surveyed.

The authors of SRI Research on the Use of Khan Academy in Schools study cautioned that the study was “exploratory” and “preliminary” because it did not utilize a randomized experimental design. The study also did not examine the use and impacts of a rigid treatment. The teachers did not have protocols for using KA. Some sites had their own protocols for using KA as an instructional tool, but the teachers in several other sites were able to use KA as they deemed appropriate. It was also reported that many of the teachers who participated in both years of the study modified how they used the program in the second year. For example, the teachers in Site 1 used KA routinely in the first year of the study when usage was mandated by administration but used it sparingly in the second year when usage became optional. Site 2 changed their instruction to a school-wide self-paced competency-based model in the second year of the study. In the first year pacing was determined by the teacher, but in the second year
learning became more individualized at Site 2. In the other sites where teachers had at least some autonomy, some changed their usage model as computers became more accessible in the second year and as they began to develop personal preferences for one model over another. Some teachers used KA to supplement traditional teacher-led instruction in the first year of the study and began using other models like flipped learning and Station Rotation in the second year.

The Michael & Susan Dell Foundation conducted a quasi-experiment that focused on blended learning that was released in May of 2014. Their report was self-published. The Blended Learning Report was written by 3 of the 5 researchers who authored the SRI Research on the Use of Khan Academy in Schools study. This non-anonymous report reviewed the use of blended learning as an instructional strategy in several charter management organizations. KA was used by two piloting high schools in the Summit charter network (Summit Rainier and Summit Tahoma). It is worth mentioning that in 2014, the Summit charter network began receiving technical and financial support from Facebook CEO Mark Zuckerberg and his wife, Priscilla Chan (Jacobs, 2017). The Summit schools’ sample included three teachers and 220 ninth grade student participants. Two of the participating teachers received formal training and ongoing coaching from KA staff. The two Summit high schools may have been Site 2 of the SRI study. Teacher interview and observation data were collected in one to two day site visits in the fall and spring of SY 2011-12. The methodology was described as “quasi” experimental due to its inability to distinguish outcomes related to the use of instructional technology from the conventional instruction the students received. The study also lacked a randomized control group.

Unlike most of the sites studied in Research on the Use of Khan Academy in Schools, Summit teachers had a protocol for using KA. KA was used 30-60 minutes per day 4 days a
week for about two months at the beginning of the school year to fill in learning gaps. Students were also expected to use KA at home for at least one hour per week for the first month of school. After the initial two months, KA was used as a supplemental learning tool and was used primarily to provide individualized learning in a Station Rotation model where some students worked on KA, a small group worked with the teacher, and the remaining students either worked independently or worked on projects. KA time was typically spent doing exercise sets. Students viewed an average of only 29 videos for the school year. Videos were only viewed optionally as a “last resort” (p. 130). The teachers used the data collected in KA’s dashboard to plan the small group instruction. Students were expected to set and monitor their progress on weekly goals. Project-based collaborative units became an integral part of instruction in the second semester of the year.

As with the SRI study, the teachers’ perceptions of KA were generally positive. The three teacher participants agreed that students were highly engaged when using KA and would recommend KA to others. The majority believed that KA provided students with an opportunity to learn on their own and to regulate their learning. The achievement results were also positive. The study’s “exploratory” quantitative analysis revealed that the students who spent more time doing KA exercise sets did better than expected on the California Standards Test (CST) and the Northwest Evaluation Association Measure of Academic Progress (MAP) but cautioned against making causal assumptions based on their results. Student perceptions of KA and blended learning were not assessed.

The Michael & Susan Dell Foundation commissioned an earlier report (Bernatek et al., 2012) on the use of blended learning in several charter school networks. Their descriptive report was not scientific. It did not state a methodology, theoretical framework, or use randomized
controls. The teachers reportedly liked KA’s ability to keep them informed of the students’ progress. It helped them to know when students were behind or if students had met or exceeded expectations enabling the teachers to modify their future instruction. The students reported liking the immediate feedback and knowing which concepts they had mastered or still needed to work on. Additionally, the teachers reported that the student-to-student collaboration and student-to-student tutoring had increased, and the school leaders reported “an unusually high number of students on task” in the blended classrooms (p. 15). The outcomes of this earlier expository report were mirrored in SRI’s and the Dell Foundation’s subsequent reports.

Light and Pierson (2014) qualitatively studied the use of KA in five low income Chilean schools. The researchers noted that Chilean mathematics classrooms (without the use of KA) often followed the standard model of teacher demonstration on the board, individual or small group student practice, and then teacher assistance that was seen in many classrooms around the world. The peer-reviewed and published research included eight case studies of 4-12th grade teachers. Data were collected in the form of observations and interviews over two weeks. Thirty-two students were interviewed. KA was primarily used for practicing previously taught material and for review. The teachers felt KA supported both enrichment and remediation and created an opportunity for students to control their own learning. The teachers required students to complete exercise sets but did not require the viewing of the instructional videos in part due to Internet bandwidth issues. Several teachers posted the students’ accumulated energy points because the teachers believed competition would motivate the students. The teachers felt that the students completed more exercises on KA than they would have with traditional paper and pencil methods. As noted in SRI’s and the Dell Foundation’s reports, the teachers recounted that the students collaborated with each other more and asked more questions to the teacher than was
usual for a traditionally instructed class. The teachers felt that prior to the KA study, the students only received superficial assistance from each other. The researchers asserted that, “KA transformed the typical peer-to-peer interaction from the exchange of correct answers to one of facilitation and guidance…Peers became facilitators rather than answer sheets.” (p. 111). The teachers also stated that students were motivated by the immediate feedback and their ability to work at their own pace. Some students called the program “fun,” “dynamic,” “motivating,” and “game-like” (p. 111). The researchers detected that KA’s intricate interactive illustrations also bolstered student appeal because the images were more eye-catching than any illustrations and models that could be displayed in a textbook or created by most teachers. In the student interviews, some students indicated increased confidence in their abilities to do mathematics as a result of the energy points they earned. The researchers concluded in the assessment of student perceptions, “Because Khan Academy provides infinite opportunities to practice exercises and get things right, students have many opportunities to feel successful in their learning…with practice, they could learn, achieve, and master something” (p. 117).

Another recent study in Australasia also cited positive student perceptions of KA. Muir qualitatively studied 120 grade 7-9 students to ascertain their perceptions of KA videos (2014). Data were collected in an online survey, and 30 students participated in focus-group interviews. The students were not required by their teachers to use the KA program. Blended learning as it was defined by Staker and Horn (2012) did not occur; instead, the students used KA on their own either at school or at home to voluntarily supplement their teachers’ instruction. The students reported liking the simplicity of the videos, the ability to control (re-watch) video viewing, and preferred watching the videos to asking siblings, teachers, or parents for assistance. The researchers believed the program to be an effective supplemental learning resource.
An unpublished dissertation focused on the use of KA in secondary mathematics instruction. Wiginton (2013) used a mixed methodology to study the impact of flipping on self-efficacy, achievement, and learning styles for Algebra I students. The dissertation contained substantially more data in the form of first person quotes than the other reviewed studies and painted a clear picture of the students’ and teachers’ experiences. The data included surveys, observations, and achievement data. Kranzler and Pajares’ self-efficacy scale MSES-R (1997) was used as a student survey.

One teacher taught the two blended learning classes that used the flipped learning model as the treatment group. One class focused on flipped active instruction and the other flipped mastery instruction. The students in the flipped active course were assigned teacher-made instructional videos for homework and solved exercises in collaborative small groups during most of their class time. The flipped mastery students were given the choice of watching instructional videos from KA or their online electronic textbook (InterAct Math) tutorial program for homework. All of the interviewed students chose to work on KA. Their reasons were not stated. KA exercise sets and small group active learning mathematics tasks were completed during class time. The students worked on individual topics from a list provided by the teacher on the chosen tutorial program until the program indicated that mastery was achieved. Mastery required success on the online tutorial program and on an aligned teacher created quiz. A score of 80% was required on each quiz to advance to the next topic. The teacher described her flipped mastery class as a “three-ring circus juggling act” because managing a class where students simultaneously worked on different topics created a mildly chaotic learning environment (p. 106). The students in the third comparison class were taught traditionally by a second teacher.
The third class of students were also Algebra I students at the same school as the two classes of treatment students. The total sample included 66 mostly ninth grade students.

The treatment teacher cited increased teamwork, student engagement, and student ownership of their progress as noted in other reviewed studies. She believed the positive non-achievement outcomes were the greatest in her flipped mastery class. She said, “It is amazing for me to see the teamwork in that mastery classroom. Kids are trying to achieve on their own…It’s beautiful to see” (p. 107)! She explained the excitement of the students’ self-propulsion towards mastery in her classroom. Her students were often joyful when mastery was achieved. The teacher stated, “Last week I told this girl that she made an 84 [%] and tears started streaming down her face…She was like, “Y’all, I just mastered!” And the class clapped and she was grinning from ear-to-ear…you know, it is amazing” (p. 107)! The teacher said several students actually cried when they reached 80% on a topic that they had struggled to master. The MSES-R results for the students in both flipped treatment groups showed a statistically significant effect (.128) on student mathematics self-efficacy. Student belief in their abilities to successfully do mathematics increased.

Overall, the students in both treatment groups spoke favorably about the self-paced structure and increased level of control of their learning in their blended learning classrooms. The students particularly liked the ability to rewind, review, and re-watch instructional videos. A student remarked, “You’re not lost while they are going on to chapter nine while you are still confused about chapter six” (p. 118). The students felt that the self-directed learning environment alleviated some of the stress of learning mathematics, but the structure of the course required them to manage their time more wisely. The students had to make personal decisions about retaking quizzes to receive higher grades or to be satisfied with the 80% mastery and move
on to learn more topics. The students reported overall satisfaction with the flipped mastery instructional style; however, a few negative themes emerged in the student interviews and focus groups that had not been significantly mentioned in other studies.

Some students vocalized a strong preference for assistance from the teacher rather than receiving assistance from a peer or accessing the hints on KA. Wiginton found that a vast majority of students thought that peer tutoring was ineffective. Students sometimes thought they wasted their time asking peers questions when the peer also did not know how to solve an exercise. The expertise of the teacher was also preferred over watching the instructional videos. The researcher surmised that this preference was the consequence of the hint feature on KA. If students accessed the hint feature, they were not given credit for correctly answering the exercise and had to restart the exercise set. Asking the teacher for assistance provided greater assurance of getting the exercise correct. Another student dislike was the inability to ask real-time questions when viewing the instructional videos. A student said, “I like being taught by a teacher more than a video. If the teacher is teaching you, you can ask her questions, but you can’t ask questions to the video” (p. 112). (It is worth mentioning that KA added a discussion board to each exercise set where real-time questions can be asked after this study was conducted.) Despite the lack of inter-activeness of the instructional videos and a few other student complaints about the quality of peer-tutoring, there was a statistically significant positive difference between the achievement of the flipped classes and the traditional class (effect of .383) after controlling for prior achievement. There was no significant difference between the two flipped classes (p. 84). The teacher felt that the blended flipped mastery classroom benefited students in ways other than the academic gains they achieved. She felt that students became
more responsible and more willing to direct their own learning. She said, “I think that the kids that have been in the flipped mastery class are going to succeed better” (p. 107).

A leading research organization in the United Kingdom, the National Foundation for Educational Research (NFER), partnered with Nesta, a London based foundation committed to innovation, to qualitatively explore the use of flipped learning in nine schools over a period of four to six weeks (Straw et al., 2015). Their report was self-published. The sites included three secondary and one middle school in England and five secondary schools in Scotland during the SY 2014-15. One to three flipped mathematics classes were studied in each school site. Six of the nine participating teachers elected to flip instruction in classes they deemed as having higher abilities. Only one teacher chose to use flipped in a class described as having relatively low abilities. The teachers indicated beliefs that students with perceived higher abilities would be more amenable to independent learning.

Data were collected through interviews, pre- and post- surveys, focus groups, and classroom observations. The teachers were asked to use KA to flip instruction but were not asked or required to use a particular instructional protocol. Several of the teachers also assigned instructional videos from other online sources like Hegarty Maths (www.hegartymaths.com) and MathsWatch (www.mathswatch.co.uk). The findings echoed the results of earlier studies on flipped and blended learning. Some students and teachers indicated a preference for face-to-face instruction with the teacher. Home access to technology and the students’ willingness to view videos for homework were challenges. Two of the sites overcame these hurdles by providing opportunities for the students to view videos at school either in class or during non-instructional times like lunch or afterschool rather than at home.
Most of the teacher participants reported that the flipped approach enabled more time for deeper teacher-to-student interactions and student-to-student discussions and helped students to regulate and “develop independent study skills” (p. 16). The students learned how to learn on their own, and the teachers had more time to guide and facilitate learning rather than directing learning. The use of projects was not mentioned, but the researchers alluded to problem-based learning by citing more opportunities for higher-level teacher questioning.

The researchers stated, “Some students who previously said that they ‘hated’ mathematics were now reporting that they liked it…” (p. 23). The report included compelling student and teacher statements: “Khan Academy makes maths lesson a lot easier and a lot more fun…” and “One student who isn’t particularly keen on maths told me that she just loved it because she’s got a better starting point…other jumped on board and said, ‘so do I’” (p. 23). “Most” of the teachers reported favor for flipped learning and planned to continue using instructional videos to introduce at least some topics; however, several challenged the idea of requiring students to view the videos at home. In future instruction, these teachers planned to provide either whole group or individual viewing time during class.

Overall the NFER and Nesta reports mirrored the findings of Wiginton’s (2013) dissertation on flipped learning, but Wiginton’s study included significantly more detail. For example, the NFER report posited that flipped learning increased student confidence by stating, “Another important impact was students’ increased confidence in mathematics. This was related to their increased knowledge and understanding gained through regular homework and independent learning which had resulted in a realisation that they could be successful in mathematics.” (p. 24). However, the claim was only substantiated with a one sentence quote from a participating teacher. The findings also included broad terms like “many” and “most” on
the objective conclusions. For example, the report said “most” instead of the actual number of
the nine teachers that planned to continue using the flipped learning model rather than clearly
stating an exact number of the small number of teachers. Further, the possible ramifications of
the six teachers’ initial choice to pilot flipped learning in the classes that were perceived to have
higher abilities was not well developed. The teachers’ positive predispositions and other factors
may have tainted the data from these six sites. Lastly, the study focused solely on the use of the
instructional videos. Previous studies Research on the Use of Khan Academy (Murphy et al.,
2014a), The Blended Learning Report (Murphy et al., 2014b), and Increasing Student
Engagement in Math: The Use of Khan Academy in Chilean Classrooms (Light & Pierson, 2014)
showed that most of the students’ time on KA was spent completing the exercise modules rather
than viewing the instructional videos. The report may have been more elucidating if researchers
had conducted a more comprehensive exploration of the KA program.

**Blending with other adaptive tutorial programs.** Pane, Griffin, McCaffrey and Karam
(2014) conducted a large scale empirical study of the effectiveness of blended learning in middle
and high school mathematics classrooms that showed no impact on non-achievement outcomes.
Their study examined the effects of using Carnegie Learning’s adaptive tutorial program
Cognitive Tutor Algebra I (CTAI) on more than 25,000 students over two years. The
participants were from 73 high schools and 74 middle schools in 51 school districts across seven
states. The public and parochial sites contained rural, suburban, and city schools. Most of the
students were in the ninth grade. The study used a randomized controlled design and assigned
pair-matched treatment and control groups. The teachers in the treatment group were trained
prior to using CTAI but did not receive ongoing support as the teachers did in the SRI, Dell
Foundation, and Light and Pierson studies. The CTAI program expected students to use the
tutorial program during class time about two days per week and required teachers to minimize lecture.

Only quantitative data were reported. The Algebra Readiness Exam was given as a pre-test and the Algebra Proficiency Exam was given as a post-test (neither test was formally cited). The students were also given a pre- and post- 17 item survey created by the researchers designed to assess the students’ confidence and attitudes (including enjoyment and plans to study mathematics in the future) towards mathematics. The survey was based on Fennema and Sherman’s (1976) assessment. The participants in the study showed no significant change in attitudes or confidence. Only one survey question that referred to the usefulness of computers in learning mathematics showed a significant (positive) change. There was also no meaningful impact on student achievement in Year 1 and in Year 2 for middle school students. However, a significant effect of .20 was shown for high school students in Year 2 (p. 141).

The results of the study were confounded by several factors. The students in the treatment group scored significantly below the control group on the proficiency pre-test. The researchers conjectured that teachers and administrators in the treatment group schools may have assigned lower achieving students to the treatment condition thinking that the program was more suitable for lower achievers. Secondly, the CTAI developers recommended that 40% of class time be used to work on CTAI and 10% less time be dedicated to lecture styled note-taking (p. 140). The remaining class time was to be dedicated to student centered activities, but the researchers believed that due to a lack of positive results in Year 1 the teachers may have reverted back to more traditional teaching methods in Year 2. Fidelity issues may have impacted the results.
A 2012 study commissioned by the Kentucky Department of Education showed comparable results with similar fidelity concerns (Cavalluzzo, Lowther, Mokher, Fan, & Regional Educational). The quantitative randomized controlled study of about 7,000 Algebra I students from 25 sample schools showed no statistically significant effect for achievement or for future mathematics course enrollment. The teachers in the treatment group used the state’s Kentucky Virtual Schools (KVS) web-based online tutorial to supplement instruction. The teachers were trained to use the KVS program 40% of class time and to use activities such as journal writing, discussions, and reflection for 60% of class time. Future enrollment data were used as a measure of impact on student attitudes towards mathematics. The study results showed no statistically significant difference in student achievement results or in student enrollment in future optional mathematics courses.

The National Center for Education Evaluation and Regional Assistance (2009) conducted a study of educational software products that also showed no statistically significant effect on student achievement. Researchers Barbara Means and Robert Murphy of the SRI foundation were thanked for their assistance with designing the study. The report was published by the U.S. Department of Education. The examined mathematics products were Cognitive Tutor (Algebra I), Larson Algebra I, Achieve Now (grade 6), and Larson Pre-Algebra (grade 6). The uses of the products ranged. All of the programs were described as skill building programs with some element of problem solving. Each tracked progress data for use by the teacher. Student and teacher perceptions of the products were not examined in this study.

The Rand Corporation examined both achievement and teacher survey results for 23 public charter schools that used technology to personalize instruction in a study funded by the Bill and Melinda Gates Foundation. The sample for their Early Progress: Interim Research on
Personalized Learning (2014) included almost 5,000 grade K-12 students. The participating schools used a variety of unspecified learning models to integrate technology into instruction, but each student followed a “customized path” that changed according to “his or her learning progress, motivations, and goals” (p. 6). Reportedly, 86% of teachers used self-paced learning. Student progress data generated from instructional technology programs were used by three-quarters of the teachers to plan future instruction specifically to plan enrichment and remediation for individual students, for reflection discussions with students, and determining student groups. Competency-based learning was widely used in the participating schools (students progressed on a personal learning plan after each topic was mastered). The achievement results of the students in the participating schools were substantial when compared to the control group. Almost two-thirds of the schools showed statistically significant gains in mathematics with the most significant gains being from students with initial achievement in the lowest quartile. The overall mathematics achievement effect size was .41.

The unpublished results were promising but were exploratory. The researchers explained that the study will continue for another year. Much of the non-achievement data focused on the teachers’ perceptions of general (administration, technology, facilities, and professional development) support needed to personalize the students’ instruction. The participating teachers expressed concern for the cultural shift that was needed for parents to accept and understand how grading was transformed in a mastery learning driven classroom. Grading shifted from the traditional percentage of correct answers or completed tasks to a measure of understanding and competency. More than half of the teachers also cited student disciplinary issues and the time needed to plan personalized learning as significant obstacles (p. 26).
The Rand Corporation completed a follow up study entitled *Continued Progress: Promising Evidence on Personalized Learning* (Pane et al., 2015). The specific technology that was used was not stated or described in either study but was presumed to be adaptive because all of the participating schools sought to create individualized learning experiences for students. The study was more detailed than the first. It continued following the original schools and added an additional 39 for a total of 62 schools and about 11,000 students. The results were consistent with the first report. The participating charter and public schools served predominately minority and high poverty students. An adaptive “ability” standardized assessment (Northwest Evaluation Association Measures of Academic Progress (MAP)) was given two years for a greater analysis of student progression. Overall, the students’ gains in mathematics showed an effect size of .27. In other words, a student with a median score showed an 11 percentile gain over the two years of the study. After the second year of personalized learning, the participating schools MAP results were above the national median. The results were most substantial for the participating elementary and middle school students and the students with the lowest initial achievement scores. The authors suggested that the effect size from the initial study of .41 may have declined to .27 due to the different compositions of the two samples of participants but did not speculate specifically on how the changes may have impacted the data.

Blended learning was not specified as an instructional strategy, but “the use of technology for personalization was widespread” (p. 34). There were no universal protocols for personalization; however, the schools with the highest achievement outcomes overwhelmingly used technology to generate data to inform instruction as well as to provide progress data for teacher-to-student consultations. These achievement gap narrowing schools also used small group instruction and flexible learning environments where learning time was structured to
address student needs. These schools typically did not adhere to traditional constraints such as school bell/period schedules, stationary school furniture, immovable classroom walls, and so on. Student schedules were flexible depending on their learning needs and classrooms contained traditional furniture that could be quickly rearranged to form groups and non-traditional furniture like small sofas. Students were assigned to traditional grade level classes and were given grade level assignments but also had designated times when (individualized learning path) assignments were given based on individual assessment scores. About one-third of the teachers reported using project-based learning as a means of providing students with individualized learning paths and choice. The teachers cited difficulties using projects that addressed grade-level standards to students with existing knowledge gaps. The researches also noted that the schools struggled with implementing a competency-based (mastery-based) model of instruction due to pressures to prepare students for grade level state standardized testing. This concern was not directly mentioned in the initial study *Early Progress: Interim Research on Personalized Learning* (2014) where competency-based instruction was described as predominant among the participating schools. Only some elements of competency-based instruction were evident during the second study.

In a survey given to students in grade 6 or above at 32 of the participating schools and a national comparison sample of an unspecified number of students, the students at the personalized learning schools were more likely to indicate having learning choices, receiving teacher support, and doing more cognitively demanding tasks like participating in high-level discussions and debate but were significantly less likely to report the enjoyment of school. This finding was not discussed in the conclusions of the report. It is hoped that future studies delve more deeply into the attitudinal impacts of personalized learning.
Blending with non-Khan Academy instructional videos. O’Dwyer, Carey, and Kleiman (2007) used a quasi-experimental design to examine the effectiveness of a program intended to provide algebra instruction to students in rural Louisiana where teacher shortages were common. The program, the Louisiana Algebra I Online Project, connected licensed mathematics teachers remotely (online) to unlicensed teachers and students. The sample included 257 students from 18 classes in six districts. The classes were held in computer labs and took place during a standard school class period. Instruction was delivered via Blackboard and emails from the licensed teacher. Students also used a textbook, graphing calculators, animated tutorial instructional videos from an unstated source, and other internet tools. The curriculum was developed by two state organizations and was purported to be aligned to NCTM and Louisiana state standards. The unlicensed classroom teacher provided classroom management and some content and technology assistance. Many of the unlicensed teachers were in licensure programs or were elementary and middle school teachers who were licensed in other areas. The online teacher graded all assessments, communicated daily with the face-to-face unlicensed teacher, sometimes video streamed with the class, and was the teacher of record. The presence of two teachers, one remote and one face-to face, made this model of instruction atypical of the other reviewed instructional models. It was not clear if the students could learn at their own pace or if students had individual learning paths.

The participating school districts provided a comparison group of Algebra I students that was similar in demographics to the treatment group and was taught by a traditional face-to-face licensed mathematics teacher. Quantitative data were collected from the treatment group and from a comparison group. The data included pre- and post- test and survey responses. The statistical analysis of the achievement test results indicated that the treatment group’s scores
were comparable to the comparison group. There was no statistically significant difference. The survey results on the non-achievement outcomes indicated that students liked “using technology to learn math” (71.8%), collaborating with other students (68.5%), activities (44.6%), and the rigor of the curriculum (32.9%) (p. 298). As noted in other studies, most students cited that adjusting to the more self-directed and independent learning environment was an obstacle. Almost 80% of the treatment students had at least a satisfactory learning experience which was substantially less than the comparison group’s nearly 94% (p. 300). Further, the comparison group was slightly more confident than the treatment group. This blended model was designed to satisfy the state’s need to supply rural schools with instruction from licensed teachers and provided seemingly comparable achievement results as consistent with meta-analysis data on blended versus face-to-face instruction (Means et al., 2013). Yet, the data also showed that the online program had a negative impact on non-achievement outcomes. In addition to fewer students reporting satisfaction with the instructional program, the cost of administering a program that required two teachers for each class of students was likely prohibitive.

The Flipped Learning Network’s (2014) report highlighted a few anecdotal stories and dissertations where teachers had implemented flipped learning and had also reported achievement data. The two K-12 mathematics reports were from a CNN news blog and a dissertation study. The report also referred to sizeable survey research data reported by Project Tomorrow, one of the network’s partner organizations.

Mother and daughter Advanced Placement® Calculus teachers (in different east coast cities) blogged about flipping their classes. Both created their own videos, assigned the videos as homework, and used class time primarily for working on teacher-selected exercises and receiving help from the teacher. The daughter said the blended teaching style was “erasing the
anxiety level while maintaining, and even increasing, the rigor of the course.” Seventy-eight percent of her students scored a 4 or 5 on the AP exam in comparison to 58% previously. The mother reported that 80% of her students scored a 4 or 5 on the AP exam (50% had a perfect score) and said, “the flipped classroom has allowed me to create a calm, inspiring environment where students can learn, thrive and feel supported…” (Roshan & Roshan, 2014).

Mathematics teacher Clark (2013) quantitatively studied the impacts of flipped learning on 42 of his ninth grade Algebra I students in rural Louisiana for his dissertation study. The students were expected to view instructional videos, listen to podcasts, watch presentations, or to complete more traditional assignments such as readings for homework. The videos were created by Clark. Class time was described as being spent on “hands-on activities,” “real-world applications,” and independent practice although no examples of the non-traditional instruction were provided or detailed (pp. 48-49). Qualitative student interviews, notes, and focus group data were collected. Additionally, quantitative pre- and post- survey and assessment data were collected. The Student Perception of Instruction Questionnaire (SPIQ) (not cited) showed what the researcher described as “minimal variation” between the students’ perceptions of the flipped instruction and the traditional instruction. However, the dissertation did not report a statistical analysis of the data. The data showed increases in several areas including student collaboration, communication with the teacher, and perceptions of learning. The lack of an explanation of the limited analysis made it difficult to agree or disagree with Clark’s conclusion. The questionnaire also included a few “and” statements that might have confounded an examination of the results such as “The learning activities focused on real life applications and improved my learning.” (p. 69). Overall, the study did not contribute to the body of knowledge on blended learning.
Attitudes and perceptions on online learning were elucidated by nonprofit Project Tomorrow©. The organization annually conducted a national Speak Up survey given to students, parents, administrators, and community members and reported their findings on their public website. The report did not include the traditional trademarks of published scholarly studies such as a comparison group but did include its methodology and an invitation to contact the organization to answer any questions regarding the study. According to their website (http://www.tomorrow.org/speakup/states.html), the “The Speak Up data represents the largest collection of authentic, unfiltered stakeholder input on education, technology, 21st century skills, schools of the future and science instruction” (Project Tomorrow, 2014). Indiana, North Carolina, Alabama, Massachusetts, and Nevada had the highest student participation rates. Schools voluntarily signed up to participate and facilitated completion of the online survey. The surveys were completed from home, school, or any online computer. More than 3.4 million surveys have been completed since the survey’s inception. Fifteen to 20 annual focus groups were also conducted to further inform the organization’s analysis process.

In the fall of 2014, 431,241 K-12 students completed the Speak Up survey. There were more than a half-million total participants. Participating school leaders reported that nearly one-third of their teachers used instructional videos found online. School personnel reported websites such as YouTube, Khan Academy, and NASA as being used most often, but also reported that the number of teacher created videos was on the rise. Nearly half of students reported regularly using videos for homework. Forty percent of students reported finding the videos helpful. Interestingly, only 7% of students in grades 6-12 reported that they had a “flipped class where students watch/listen to lecture at home and then use the class time to do projects or get homework help” (Project Tomorrow and The Flipped Learning Network, 2015).
The students perceived themselves as watching instructional videos for homework but must have believed class time was used for purposes other than doing projects or getting homework help. This student belief echoed SRI’s reports where only one of the nine studied sites was observed to have routinely incorporated the use of projects and active learning into its instructional program.

Of the grades 3-12 students, about half indicated that technology enabled a self-paced learning environment, provided an opportunity for students to control and guide their learning, and addressed their learning styles. It was not known if the participants of the online survey had a greater access and exposure to technology than the national population. The survey results could have been positively skewed due to the nature of online surveys. It was also noteworthy that the primary author of the report was Blackboard. Blackboard commercially produced a learning management system which was used to support online learning in K-12 and in higher education.

**Blending in higher education.** Yushau (2006) used Aiken’s (2000) Mathematics Attitude Scale to compare the attitudes of pre-calculus students in a post-secondary Saudi Arabian university preparatory program. The students had graduated from secondary school but had not begun their undergraduate programs. The participants were randomly selected to participate in either the traditionally instructed control group or the treatment group. The treatment students used WebCT an online educational course platform similar to the commonly used Blackboard or Edmodo. WebCT was expected to be used at least once a week in lieu of traditional instruction. Students were also expected to use it as an independent learning resource when needed in their time outside of class. The site included practice test questions with solutions, interactive self-assessment that provided immediate feedback, and a discussion board. A quantitative comparison analysis of the students’ pre- and post-scores was conducted. The
results indicated that the students’ attitudes towards mathematics declined slightly (but not statistically significantly) after their participation in the blended learning condition. However, the validity of the study might have been questionable because the original pre-test sample included 65 students, but only 50 students completed the post survey. The researcher speculated that the students who were more dissatisfied may have opted to complete the survey. The blended learning participants complained to the researcher of feeling “overworked” and may have felt that they were required to do more work than the traditionally instructed group.

Similarly, some students in a college level statistics course that used a flipped form of blended instruction also resented the independent learning required by the instructional style. Wilson (2013) traditionally taught an introductory statistics course to social science majors at a Midwestern university for 10 years and studied the achievement and non-achievement outcomes after she flipped the course. Lecture was significantly reduced in the flipped course. Most of class time was spent on activities, reflections, and with some review of homework. Seat time was not reduced due to the blended learning condition. The students were required to read the course textbook for homework and were advised to watch corresponding KA videos. The students were assigned to learning groups. The primary role of the groups was to check and discuss homework before it was collected. Although the overall results were positive, some students disliked the increased personal responsibility. One student commented, “I feel as though I have to teach myself…” (p. 198). Wilson reflected that future studies might examine personality traits or student dispositions that are more receptive to the self-directed learning experienced in a flipped or blended classroom.

Wilson’s sample compared two classes of 20-25 students in the flipped course fall 2011 to two classes that she taught traditionally in SY 2010-2011. She quantitatively and qualitatively
compared student course evaluations. Forty-one percent of students in the flipped course said the KA videos were at least “somewhat helpful” and 96% said the learning activities were at least “somewhat helpful.” On the end of course evaluations 5-point scale, the flipped students scored the flipped course as “excellent” with a 4.40 in comparison to 3.85 when the course was taught conventionally, and the teacher was rated as “excellent” with a 4.70 up from 3.95 respectively. The exam grades of the students in the flipped course were 6.73 points higher, and the final grades were nearly 10 points higher. Generally, the flipped course improved student attitudes towards the statistics class, the instructor, and increased student achievement.

Discussion

There was no singular way that KA and similar tutorial products were used in K-12 or higher education mathematics classrooms. The uses of KA have evolved since its inception. K-12 teachers who used KA to blend instruction for multiple years often modified their usage from year to year and as technology became more available (Murphy et al., 2014a). Many K-12 teachers used some form of a small group Station Rotation model or used an online instructional technology whole group for one or two days a week (Murphy et al., 2014a; Murphy et al., 2014b; Wiginton, 2013). Only about one in five teachers that used KA as a supplement assigned KA as mathematics homework (Murphy et al., 2014a). Of the teachers that used KA (and similar products) to blend instruction, the required KA usage time varied from the two charter schools that used the program robustly at the beginning of the year for more than two hours per week (Murphy et al., 2014b) to schools where KA was not assigned and was only used by students when they chose to use it (Muir, 2014; Murphy et al., 2014a). The students infrequently accessed the instructional videos when viewing was not required by the teacher, and the vast majority of KA time was spent doing the exercise sets (Light & Pierson, 2014; Murphy et al.,
The students used the instructional videos sparingly as a last resort (Light & Pierson, 2014; Murphy et al., 2014a). The teachers typically used the KA dashboard data as a formative assessment of student progress and utilized the data to inform and alter future whole group and small group targeted instruction (Bernatek et al., 2012; Murphy et al., 2014a; Murphy et al., 2014b).

Only five of the reviewed studies mentioned the routine use of project based or activity based instruction (Cavalluzzo et al., 2012; Murphy et al., 2014a; Murphy et al., 2014b; Pane et al., 2014; Wilson, 2013) despite Khan’s recommendation for engaging, collaborative, and real world activities to fill the time not used on KA (Khan, 2012). Of the examined K-12 schools and districts only the two Summit schools, Summit Rainier and Summit Tahoma, referenced a formalized protocol for regularly partnering project based constructivist learning with a web-based online tutorial program (Murphy et al., 2014a; Murphy et al., 2014b). Instructional programs in at least two studies recommended that learning activities be paired with online instruction but had fidelity issues (Cavalluzzo et al., 2012; Pane et al., 2014). The researchers believed that projects and active learning strategies were rarely used because the teachers did not perceive them as increasing student achievement (Cavalluzzo et al., 2012; O'Dwyer et al., 2007; Pane et al., 2014). Of the teachers who used engaging and collaborative activities and projects, many likely did so by choice and not as part of a prescribed program (Murphy et al., 2014a; Pane et al., 2015).

The teacher perceptions of KA and similar online tutorial programs were consistently positive in the examined studies. The teachers felt that the structure of the programs created environments where students worked on individualized learning pathways and promoted self-regulatory skills. The students took ownership of their learning and matured in their abilities to
manage their own learning (Bernatek et al., 2012; Light & Pierson, 2014; Murphy et al., 2014a; Murphy et al., 2014b; Pane et al., 2015; Straw et al., 2015). The teachers who utilized mastery learning or competency-based formats (where students were required to master a topic before advancing to another topic) reported the greatest ownership of learning, self-regulation, and management skills in their students (Wiginton, 2013). They reported more increased observations of self-efficacious student behavior than the non-mastery formatted classes (Wiginton). The students became more eager to complete mathematical tasks. As the students succeeded on the exercise sets, their sense of self-confidence in their willingness to do mathematics increased (Bernatek et al., 2012; Light & Pierson, 2014; Murphy et al., 2014a; Roshan & Roshan, 2014). One teacher reported student jubilation as they mastered topics (Wiginton, 2013). Teacher concerns regarding mastery learning were that it required shifts in cultural norms regarding learning, grading, and assessment and was difficult to manage in schools where students were divided by traditional age-based grade levels (Pane et al., 2015; Rand Corporation, 2014). When mastery or competency-based learning occurred, grades shifted towards a measurement of understanding and away from less meaningful measures of task completion. The responsibility of learning moved toward the student. Teachers also needed more time to plan individualized learning in comparison to planning traditional whole group instruction (Pane et al., 2015).

Many of the student participants appreciated the ability to control their learning (Bernatek et al., 2012; Light & Pierson, 2014; Murphy et al., 2014a; Pane et al., 2015; Project Tomorrow and The Flipped Learning Network, 2015; Roshan & Roshan, 2014; Straw et al., 2015; Wiginton, 2013; Yushau, 2006). The students liked having an accessible resource, but at the same time they continued to appreciate the expertise of their teachers. Some students felt the
teacher remained the infallible expert in the classroom and did not value peer communications as
learning experiences (Light & Pierson, 2014; Murphy et al., 2014a; Wiginton, 2013). Younger
students were motivated by the points and badges system more than senior high school students
(Light & Pierson, 2014; Murphy et al., 2014a). Most students enjoyed the independence of
learning using instructional software, but some resented having to learn on their own (Wiginton,
2013; Wilson, 2013; Yushau, 2006). Future studies might analyze if resentment is different for
students who achieve at different levels or who have had more traditional teacher directed past
learning experiences.

The reviewed studies indicated that student attitudes towards mathematics and self-
perceptions of their mathematical abilities were impacted positively in several studies (Murphy
et al., 2014a; Murphy et al., 2014b; Roshan & Roshan, 2014; Wiginton, 2013; Wilson, 2013), but
attitudes towards mathematics were unchanged in at least two studies (Cavalluzzo et al., 2012;
Yushau, 2006) and adversely affected in at least one study (Pane et al., 2015). The Yushau
(2006) study used an interactive learning management system, WebCT, as its online tutorial for
post-secondary students. The students were aware of the non-treatment group that was not
required to use WebCT and vocally expressed displeasure with the study’s protocol to the
researcher. The Cavalluzzo et al. (2012) study used Kentucky Virtual Schools (KVS) web-based
online tutorial to supplement instruction. The researchers speculated that the KVS program was
not implemented with integrity and the recommended instructional activities were often
excluded. This may have contributed to the programs’ lack of impact on student attitudes
towards mathematics.
Conclusions

Overall, the teachers and students reported liking the KA program and found it to be an effective tool for blending instruction. Blended learning with KA (and similar products) often positively impacted student academic confidence, opportunities for self-regulation, achievement, and attitudes towards mathematics. Although blended learning with KA may be impactful, given the results of the reviewed studies, the mastery learning style of blended learning might have the greatest potential to improve student attitudes towards mathematics. As students used online tutorial programs, the preliminary evidence in the reviewed studies indicated that student confidence to master the next topic was heightened. The culture of the learning environment also changed. The students in mastery learning classrooms possibly made decisions about their learning paths hence changing the roles of both students and teachers. Adopting a mastery learning structure required a significant shift in classroom norms. The students gained at least some control over what was learned and when it was learned. The mastery learning instructional strategy was challenged by teachers’ ability to manage students who were simultaneously working on different learning objectives. The increasing popularity of blended learning may finally replace teach-to-the-middle traditional instruction (Brighton & Hertberg, 2004) with individualized more self-directed mathematics instruction.

I hope that future studies will be rigorous and will include randomized controlled trials to add credibility to the existing research. These studies should be conducted in K-12 settings to better inform teachers and school administrators as they make programming decisions. Researchers should focus attention on schools, classrooms, or teachers that follow specific protocols for using KA and blended instruction. Studies might examine and compare the efficacy of various models such as flipped learning and the Station Rotation model and should
study participants with a variety of socioeconomic backgrounds. A wider breadth of participants should be used.

This literature review illuminated the need for scholarly study on both KA and blended learning in K-12 environments. There is a need for neutral sources to fund future research to give more credibility to the results. Many of the reviewed studies were funded by organizations like the Bill and Melinda Gates Foundation and the Michael & Susan Dell Foundation that provided financial support to KA or to the schools that were examined. The founder and executive director of KA, Sal Khan, recommended that his adaptive tutorial online program be used as a supplement to conventional teacher led instruction (Khan, 2012). Because the program is not recommended as a primary teaching tool, attributing any impacts directly to KA or any tutorial online program is problematic (Murphy et al., 2014a; Pane et al., 2015). This limitation may continue to be an obstacle because impacts of the interlocked conditions of blended learning, project- and activity- based instruction, KA, and teacher led instruction may always be difficult to isolate. Nevertheless, I expect that more robust studies will be published as schools continue to invest in blended learning.
Chapter 3: Methodology

“I believe that a technology-enhanced teaching and learning is our best chance for an affordable and equitable educational future.” Sal Khan (p. 122)

A qualitative approach was used to examine the attitudes of high school geometry students in a blended learning environment that included both Khan Academy (KA) and Project Based Learning (PBL). The methodology provided insight into the participants’ lived experiences (Merriam, 2009). The experiences were a teacher’s and her students’ interactions with the blended learning instructional strategy. I was interested in understanding their views, interpretations, and how they made sense of the teaching model (Merriam). “Qualitative research involves the studied use and collection of a variety of empirical methods…that describe routine and problematic moments and meanings in individuals’ lives. Accordingly, qualitative researchers deploy a wide range of interconnected interpretive practices, hoping always to get a better understanding of the subject matter at hand…” (Denzin & Lincoln, 2007, p. 4-5). A variety of data were collected as the teacher and her students were studied in their natural setting, the school and the classroom, as the experiences occurred.

This research was categorized as a case study. “Case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident” (Yin, 2014, p. 16). In this instance, I investigated the motivational impacts of the using blended learning which included KA, PBL, and Station Rotation (rotating small groups) instruction in one high school mathematics teacher’s third period classroom situated in an urban setting in the Midwest. The case was a bounded system because it focused on one discrete circumstance of a first year high school geometry teacher and students in one of her classes when a new instructional
strategy was implemented over two weeks (Merriam, 2009, p. 40-41). Additionally, Yin (2014) described case study inquiry as an in-depth analysis (including triangulation) of a variety of systematically collected data. For this study, the data were comprised of observations, interviews, and surveys to gain a better understanding of the participants’ realities to answer the research questions:

1. How is student intrinsic motivation to do mathematics impacted by blended learning with KA and PBL?
2. What are student perceptions and attitudes towards instruction that is blended with KA and PBL?
3. How are student feelings of competence, relatedness, and autonomy impacted by blended learning with the use of KA and PBL?
4. What particular features of KA impact student motivation to do mathematics?

**The School**

The study took place at seventh through twelfth grade Jackson School (pseudonym). Jackson School was part of a large urban school district located in the Midwest. It was within five miles of the city’s downtown business district and was within two miles of City University (pseudonym). The proximity to the university forged a longstanding partnership. The mutually beneficial relationship resulted in Jackson School serving as a host for university research projects and pre-service teacher student teaching placements, and many of Jackson School’s teachers participated in professional development and graduate programs at City University. Additionally, Jackson School’s school district recruited teachers from City University’s undergraduate teacher preparation programs.
Jackson School’s enrollment included more than 900 students that were 91% African American, 3% multi-racial, 4% white, 2% English language learners, 25% with disabilities, and nearly 100% economically disadvantaged. In school year SY 2014-15, 61.5% of the tenth graders passed the mathematics section of the state’s high school graduation test. The school district’s mathematics passing average on the state graduation test was 73.6 %, and the state average was 82.2%. Jackson School’s scores on all grade level state assessments were below district and state averages in both reading and mathematics. The state graduation test was discontinued after SY 2014-15. The state report card (SY 2015-16) assigned a grade of F (on an A through F scale) to the school’s overall grade level standardized assessment scores, an F for progress, and an F for its overall performance. The four-year graduation rate was 74.5%. Since the school’s adoption of a science, technology, engineering, and mathematics (STEM) focus in 2009, student achievement was consistently at or below the state’s targets.

The STEM program publicized on Jackson School’s website included four career pathway choices (curriculum majors), a weeklong intercession each semester, mandatory technology courses at each grade level, and an emphasis on Project Based Learning. The curricular pathways were: health sciences, engineering, technology, and plant and animal sciences. The intercessions were designed to connect academic content with real world authentic applications and careers through hands-on workshops and activities led by teachers and community members. The intercession topics posted on the school’s website included ghost hunting, barbequing meats, pastry making, philanthropy, swimming, historically black colleges and universities, artistic expression, soccer, entomology, dance, and various additional subjects. Some of the advertised senior high courses enabled students to earn college credits.
Teachers at the school received ongoing professional development in Project Based Learning and STEM education. The teachers in the school district were required to participate in a discussion on Dweck’s *Mindset* (2006) book. The book gave strategies for teaching students to persist in the learning process and encouraged the belief that intelligence was malleable (growth mindset) and not fixed. The promotion of growth mindset was a district initiative and was highlighted on the district’s website. Growth and fixed mindset posters were exhibited throughout the school building. The students participated in weekly advisory periods that focused on growth mindset, life skills, and career preparation. Growth mindset self-talk statements were displayed on the school’s hallway windows: “I like to stretch myself, take risks and learn;” “I can reach ever-higher levels of achievement;” “We thrive on feedback;” “We embrace challenge;” “We try to overcome obstacles;” “I know that growth and learning require effort;” “I persist in the face of setbacks;” and “I learn from criticism. How can I improve?” Similar statements were also displayed on television monitors in the hallways and on most of the bulletin boards throughout Jackson School.

The school day at Jackson School consisted of six daily class periods and a half-hour lunch. Each class period was 56 minutes in length. Mathematics, science, English language arts, and social studies courses met for one period of 56 minutes three days a week and one back-to-back double-period once a week. The Jackson School’s administrators planned the extended bell once a week to facilitate Project Based Learning (PBL). The teachers taught students for five of the six periods in the school day. The sixth period was a contractual planning period for teachers.
The Teacher

The teacher and school were selected by convenience. The teacher, Ms. Sunflower (pseudonym), was a recent graduate of a grant funded fellowship program at City University where I was both employed and completing my doctoral studies. She began the graduate program immediately after completing her undergraduate double majors in mathematics and a foreign language. Her undergraduate degrees were from a small liberal arts university where she worked various on-campus and off campus jobs to support herself during her studies. She worked at an amusement park, various restaurants, and was a research assistant.

The graduate fellowship at City University provided coursework towards licensure, a master’s degree in secondary mathematics education, and mentoring during her first year as a classroom teacher. The study occurred during her first year of teaching, and I was her university based mentor. My responsibilities were non-evaluative and included monthly visits, observations, co-teaching, and modeling as needed totaling about four hours per month. Ms. Sunflower taught geometry to ninth graders. She was in her late twenties and had decided to make a difference in the world by becoming a teacher. In our frequent conversations about learning mathematics, it became clear that her personal mission was to motivate children to like and do mathematics. We likely worked well together as mentor and mentee and as researcher and participant due to this mutual goal. In one of our many discussions about teaching mathematics, Ms. Sunflower shared how she was inspired by a mathematics professor in her undergraduate studies who encouraged her to persist when she was struggling to pass a class; she wanted to do the same for her students. She thought it was important for her students to know that understanding in mathematics did not come easily to her; she had to work hard to achieve success.
Ms. Sunflower was passionate about using pedagogically sound engaging and activity-based instruction in her teaching practice and conveyed disdain for teacher centered didactic instruction. In casual conversations, she often expressed the belief that teacher centered instruction bored the students and resulted in student misbehavior. Ms. Sunflower’s philosophical beliefs on the benefits of active rather than passive instruction likely led to her acceptance of the invitation to participate in this study (See Appendix B for the consent form). It was the first year of one-to-one devices (one laptop computer for each student) in Jackson School. The teachers were charged with meaningfully integrating the new technology into their instruction. Ms. Sunflower communicated her hope that her participation in the study would result in her learning and being supported in the adoption of computer assisted instruction. She expressed the desire to use the laptops to address the individual needs of her disparately skilled students and to increase student engagement.

**Ms. Sunflower’s teaching style.** Before blended learning was introduced to the students in the winter of SY 2015-16, a typical week included about three periods of problem solving activities and didactic instruction for the remaining periods. Ms. Sunflower’s instruction did not follow the traditional “I, We, You” model of daily teacher centered instruction where the teacher modeled a procedure for solving an exercise, and the students repeated the procedure to solve similar exercises (Green, 2014). Instead, her students often developed their own strategies for solving non-routine problems with the use of manipulatives, movement, and teamwork. For example, Ms. Sunflower once labeled the floor using tape in a classroom to create a coordinate grid. The grid was used for the students to move about the classroom to solve geometric translation exercises and problems. She also had the students use cut outs of squares to prove the
Pythagorean Theorem. It seemed that for a first-year teacher, Ms. Sunflower’s instruction was innovative prior to the integration of technology.

**Ms. Sunflower’s teaching team.** The ninth-grade teachers at the school worked together as an academic team. The team included mathematics, English language arts, social studies, biology, technology, and two intervention specialist (special education) teachers. The team met formally each week to resolve student discipline issues, plan intercessions and interdisciplinary lessons, and to address other topics as needed. A potluck lunch was shared weekly. The team’s classrooms were in close proximity in the multi-level building creating a cohesive learning environment. The hospitality and support of Ms. Sunflower’s teacher teammates were palpable in my many visits before, during, and after the study. I often overheard the team teachers greeting each other warmly throughout the day, giving advice, and offering assistance to each other.

**The Curriculum**

In addition to the support Ms. Sunflower received from me, her university based mentor, and the colleagues on her grade level team, the school district provided an instructional coach that visited periodically. The coach guided Ms. Sunflower in adherence to the school district’s geometry curriculum map. The curricular map aligned the Common Core State Standards (CCSS) for mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2011) to the school district’s school day calendar and the newly adopted mathematics textbook series (Springboard®). The number of days to be spent teaching each standard and the recommended pages from the textbook were identified. Related KA modules and other online resources were also included in the district’s geometry curriculum map. The achievement of Ms. Sunflower’s students was measured by a district-wide semester
exam and an end-of-year state-wide grade level standardized assessment. The semester exam and the visits from the instructional coach warranted that Ms. Sunflower closely follow the district’s curriculum map.

**Introduction of Khan Academy to Students**

Ms. Sunflower introduced all five of her geometry classes to KA in December of 2015 three months prior to the beginning of this study. KA was initially used for one class period per week to review for the district’s geometry semester exam. The students were assigned exercise modules that addressed standards taught earlier in the school year. My personal KA profile page was projected for the students’ view in the first week of KA usage. The purpose was to show students how to log in efficiently, how to view their progress information in their profile, and where to view their assigned modules. We also briefly discussed how energy points and badges were earned. During the discussion, I asked the students to read my projected Meteor badges (one of several types of badges offered on KA) and asked whether the badges were received for right answers or hard work. The third period students concluded that most of my badges were earned for hard work and only two were for correct answers. I boasted about having more than 152,000 energy points. Several students laughed and pointed out that my profile showed I had been using KA for 3 years. Their laughter and facetious remarks indicated that 152,000 points for three years of work was appropriate and was not worthy of boasting. We laughed together. The students seemed to enjoy viewing my personal profile.

**Growth Mindset**

Ms. Sunflower and I decided to use some of the activities in KA’s *Growth Mindset Lesson Plan* (https://www.khanacademy.org/educator/reference-for-coaches/how-to/a/growth-mindset-lesson-plan) in January of 2016 because we both noticed that some students easily
became frustrated while working on exercises and problems when the answer was not immediately obvious. During each class period, at least one or two students put their heads down in frustration when doing either KA or other classwork. Further, the KA lesson plan’s activities were aligned with the school district’s and Jackson School’s initiative to promote growth mindset. The KA growth mindset lesson plan was posted in the Reference Materials section of the Coaches Resources module.

We showed the students two short videos linked in the lesson plan, Growing Your Mind by KA (https://www.youtube.com/watch?v=WtKJrB5rOKs) and Neuroplasticity by Sentis (https://www.youtube.com/watch?v=ELpfYCZa87g). The two videos showed how intelligence was increased with continuous practice and persistence. The Neuroplasticity video explained how people were not born with a set amount of intelligence and that the brain physiologically grew as we learned in infancy, childhood, and adulthood. Intelligence was the result of exposure to learning experiences and ongoing effort. We asked the students some of the question prompts included in the lesson plan: How do people become more intelligent? How are our brains like a muscle? When do our brains grow the most? The lesson plan suggested that the teacher share a personal story or analogy.

I asked the students what skill they would like to learn that was not related to school. A student mentioned Parkour. She explained that Parkour was doing physical stunts like an obstacle course, often outdoors, to win a competition. She said she would like to learn to improve at Parkour. I asked if I could do Parkour. About one-third of the class yelled out “no.” The remaining students either laughed almost hysterically or yelled out “yes.” The students were divided on whether or not I could compete in a Parkour competition. I asked if I could beat Ms. Sunflower at Parkour. It is worth noting that Ms. Sunflower was about 20 years my junior and
weighed at least 50 pounds less than me. The students nearly unanimously agreed that I could not beat Ms. Sunflower under any circumstance. In turn, I asked, “Since you think I can’t beat ‘Ms. Sunflower,’ could I get better over time? Can I beat myself?” The students solidly agreed that I could continuously get better and gave me suggestions like “get fit,” “exercise more,” and “improve your diet.” The students eventually decided that with “effort and determination” I could at least significantly improve. One student commented that it might be possible for me to eventually beat Ms. Sunflower. At that point, the remaining students seemed to ponder the idea that I could beat Ms. Sunflower. I then asked if it was possible to do hard mathematics problems with effort and determination. We discussed strategies the students could use to increase their achievement in mathematics like completing homework, working on problems with their friends and classmates, asking questions, and not giving up. The students conceded that they could do difficult problems if they persisted. It seemed that our goal to foster the belief that the students could achieve in mathematics with hard work and perseverance was achieved.

**Lab Rotation Model**

We began using the Lab Rotation model of blended learning after the winter break in all five of Ms. Sunflower’s classes. In the Lab Rotation model, the students rotated whole group each day focusing on one instructional style (Horn & Staker, 2014). A typical week included one or two class periods of conventional didactic instruction, about two class periods of problem solving activities often with manipulatives or physical activity, and one or two class periods of working on KA using the laptop computers individually.

Ms. Sunflower reviewed the student performance data in KA’s dashboard each weekend and used a few exercises and problems to reteach any needed topics at the beginning of the class period the next week. We delayed using the Station Rotation model until the school district’s
Department of Performance and Accountability and the university’s Institutional Review Board approved the collection of data for the research study.

Research Design

The study was approved by the school district’s and City University’s reviewers in late February of 2016. Ms. Sunflower and I immediately began to plan how we would implement the Station Rotation model of blended learning. Ms. Sunflower chose the dates and the learning objectives to be addressed during the study based on the district’s curriculum map.

The Students

The study was conducted in Ms. Sunflower’s mostly ninth grade third period geometry class. The third bell did not include any students with identified special needs and was her largest class with an enrollment of 34 students at the time of the study. The class included one sophomore; he had previously taken and failed the course. Ms. Sunflower selected the third period class to participate in the study because it was one of two periods that were not supported by the grade level team’s mathematics intervention specialist (special education) teacher Ms. Jones (pseudonym). Ms. Sunflower and Ms. Jones co-taught for three periods each day allowing those students to learn in smaller groups. Ms. Sunflower felt the students in her third period class could also benefit from experiencing small group instruction during the study.

I explained the study to the third period class and informed the students that everyone in the class would learn mathematics in rotating small groups. I further explained that the assignments would be the same regardless of their participation. Sixteen students assented, but five did not turn in their parent consent forms. Only eleven of the 34 students in the class completed the required assent and consent forms despite providing multiple copies and opportunities to get the parent consent forms signed (see Appendices C, D, and E for the parent letter, parent permission, and youth assent forms). The student participant group included 3 boys
and 8 girls. Ten of the 11 student participants were African American. One participant was White. The ages of the participants ranged from 14 to 16. At least two participants were considered overage for ninth-grade. The reasons for being overage were unknown, but none of the participants had previously taken geometry. The participants chose their pseudonyms.

Table 1

*Participant Background Information*

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Age</th>
<th>Race</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrianna</td>
<td>16</td>
<td>African American</td>
<td>Female</td>
</tr>
<tr>
<td>Ann Marie</td>
<td>15</td>
<td>African American</td>
<td>Female</td>
</tr>
<tr>
<td>Curt</td>
<td>15</td>
<td>White</td>
<td>Male</td>
</tr>
<tr>
<td>Demarkus Johnson</td>
<td>14</td>
<td>African American</td>
<td>Female</td>
</tr>
<tr>
<td>Judy Crane</td>
<td>15</td>
<td>African American</td>
<td>Female</td>
</tr>
<tr>
<td>Maya</td>
<td>14</td>
<td>African American</td>
<td>Female</td>
</tr>
<tr>
<td>Miyaa</td>
<td>14</td>
<td>African American</td>
<td>Female</td>
</tr>
<tr>
<td>Rey Ren</td>
<td>16</td>
<td>African American</td>
<td>Male</td>
</tr>
<tr>
<td>Steph Curry</td>
<td>15</td>
<td>African American</td>
<td>Male</td>
</tr>
<tr>
<td>Vanessa Briggs</td>
<td>16</td>
<td>African American</td>
<td>Female</td>
</tr>
<tr>
<td>Wenas Nachos</td>
<td>14</td>
<td>African American</td>
<td>Female</td>
</tr>
</tbody>
</table>

**Station Rotation Model**

The Station Rotation model of blended learning resembled the classroom learning centers that were often used in elementary schools in previous decades (Horn & Staker, 2014). Small groups of students rotated through different learning centers, or stations, which focused on different learning objectives. The primary difference was that the blended learning model included a station where students worked on individual learning objectives facilitated with the use of technology (Horn & Staker). For this study, the three stations were the teacher’s small group, a project group, and a KA group. The small groups, each comprised of about one-third of
the class of students, worked in each station for a class period cycling through all three of the stations in three periods.

**Planning.** Ms. Sunflower and Ms. Jones regularly met on Saturday afternoons to co-plan lessons. I joined their meeting on the two Saturdays preceding the beginning of the study to discuss how we would divide the students into groups, the logistics of the rotation model, the instructional outline I created, and to prepare instructional materials like making copies and counting out supplies such as rulers, compasses, and protractors. We met for a total of about 5 hours in the two meetings. The final written plans specified the: (a) daily warm-ups; (b) daily procedures for teaching the teacher’s small group; (c) instructions and a checklist for the students in the project group to use to monitor their daily progress towards completion; and (d) weekly assignment list (playlist) for the students working in the KA group (See Appendices G, H, and I for the warm-up activity and daily procedures for the teacher’s small group, the project group plans, and the KA playlists).

Ms. Jones was present at our meetings because she and Ms. Sunflower decided to replicate the blended learning Station Rotation model in the three periods they co-taught each day. Ms. Jones asked me to model co-teaching in periods one and two for the first two days of the study. She was also a first-year teacher and wanted me to demonstrate how to transition the students from the whole group classroom setting to the small groups, and she wanted to observe how I instructed the group of students working on the project. I obliged Ms. Jones’ invitation to co-teach. I found the experience mutually beneficial. I demonstrated appropriate pedagogical practices for Ms. Jones and Ms. Sunflower and used periods one and two as sort of trial runs for introducing the Station Rotation blended learning model to the studied period three class. I was present in period three for the duration of the two-week (ten class periods) study. I also co-
taught in the non-studied sixth period class and periodically in other periods throughout the study.

Figure 1. Station Rotation Classroom Model

*Figure 1.* The students rotated in groups of about ten from station A, to B, to C each class period.

**Student groups.** Prior to the study, the students were seated heterogeneously in a six by six desk pattern. There were six rows of desks. Each row contained six desks for a total of 36 student desks. Each student was paired with a partner. The students’ results on the grade level state assessment from SY 2014-15 were used to disperse high achievers and low achievers in the existing seating arrangement. The seating arrangement was devised at the beginning of the school year. Prior to the study, Ms. Sunflower often asked the student partners in the first row to turn around to work with the students in the second row to form small heterogeneous collaborative groups of about four students. She stated that grouping this way also minimized student movement in the physically small classroom. Student behavior and personalities were also considered in the seating arrangement. Students who sometimes exhibited disruptive behavior (talked at inappropriate times, needed frequent behavioral redirection from the teacher,
were disrespectful to other students or the teacher, yelled out, had social difficulties, and so on) were separated. The third bell included about four students that occasionally fit this category.

Figure 2. The Classroom Arrangement

Ms. Sunflower’s Desk

(3*) (2) (1)

Student Desks

Computers

*Figure 2. The student groups consisted of two columns of students in the seating arrangement.

The existing seating arrangement was used to subdivide the students into three heterogeneous achievement groups for the study. Ms. Sunflower and I decided to continue to group the students heterogeneously because we shared the belief that grouping students homogeneously was stigmatizing. We believed homogeneous student grouping to be akin to student tracking. Tracking was the practice of assigning students to leveled classes or courses based on perceptions of ability which was widely believed to stifle the achievement of historically underserved students (Darling-Hammond, 2010) and was thought to affirm fixed mindset beliefs that only some students were and would always be good at mathematics (Delpit, 2012; Khan, 2012; Kunjufu, 2002). Fixed mindset belief, or the belief that only some students were good at math, often led to learning and challenge avoidance (Dweck, 2006).

Heterogeneous grouping often led to increased student engagement (Boaler, 2013). During the
study, the two columns of students nearest the far side of the room became group one, the two
columns in the middle were group two, and the remaining two columns of students became
group three. The heterogeneity was maintained.

The 11 study participants were dispersed in the three rotation groups. Grouping them
together would have required seat changes for all the students in the class. We decided that
changing the seating arrangement for the sole purpose of studying the 11 participants in isolation
for two weeks might disrupt the learning of all the students. Further, I co-taught all the students
in the class and was able to collect the participants’ data without the participants being in the
same group.

**Rotations.** The typical daily classroom routine during the study was the students entered
the classroom and worked independently on one to three exercises and/or problems projected on
the whiteboard in the front of the classroom while the teacher took attendance and collected
homework. The warm-up classwork served as a review of previously learned objectives, and the
problems required the students to think deeply about current topics (See Appendix H for the
daily warm-up PowerPoint slides). This routine was established prior to the study and was
designed to provide time for students to settle down from their hallway transition and acclimate
to the calm learning environment. After about five to ten minutes of quiet independent work
time, Ms. Sunflower or I reviewed the exercises and problems by reading the exercises aloud and
calling on students to assist. The student responses were recorded on the board in the front of the
room, and the students recorded the answers in their mathematics’ three-ring binder notebooks.
Ms. Sunflower graded the binders weekly for completion. (Ms. Sunflower felt the binders
provided the freshman students with practice communicating their mathematical thoughts in
writing and developed organizational skills that would be of benefit throughout high school. The

70
The students were then divided into the three station groups.

A table displaying the rotation schedule was posted on a side whiteboard for the students’ view. One group worked with Ms. Sunflower (station A), the second group of students (station B) used laptop computers to work on the exercises in their KA weekly assignment list, and the third group (station C) worked with me on a project. Ms. Sunflower’s classroom felt congested; it was the smallest of the classrooms of the teachers on her grade level team. Her room was about half the size of the neighboring classroom. The row of student desks in the front of the classroom was about three feet from the whiteboard on the front wall. There was only about one foot of walking space on the sides and rear of the classroom. We felt the classroom’s size would limit our abilities to deliver whole group instructions, engage in discourse with our smaller groups, and minimize distractions; therefore, we decided to use an additional classroom for the rotations. Station A (teacher’s group) remained seated as the station C (project group) students were directed to go to the hallway to walk together to an empty classroom on the same floor of the building. Half of the station B (KA group) students were selected each period to collect their laptops and join the project group as we walked in the hallway. I worked with approximately half of the class (station C and half of station B) each period while the other half remained in the classroom with Ms. Sunflower. The students worked at each station every third class period and rotated as follows:
Table 2

Two Week Daily Rotation Schedule

<table>
<thead>
<tr>
<th></th>
<th>Week 1</th>
<th></th>
<th>Week 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>T</td>
<td>W</td>
</tr>
<tr>
<td>1*</td>
<td>A**</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>A</td>
<td>B</td>
</tr>
</tbody>
</table>

*Note. Student groups* 1, 2, and 3 rotated through one station** A, B, and C each class period.

The class met for one 56-minute period on Monday, Tuesday, and Friday, and for nearly a double period of 98 minutes on Wednesday. The class did not meet on Thursdays. On the last day of the study, the students worked on the assignments of their choice. Because the students completed the KA assignment list and the project at their own pace, they were at various levels of completion throughout the study. The students were permitted time on the final Friday of the study to complete any outstanding assignments. If finished with all assignments, students were permitted to begin working on their KA assignment list for the next week.

**Stations.** The learning topics were introduced in the teacher’s station (A), reinforced and practiced when the students worked on the KA exercise modules (B), and conceptualized as students worked on the related project (C). On the first day of the study, the small group of students worked with the teacher, the KA group worked on previously learned standards, and the project group began working on the project.

**Teacher’s station.** Ms. Sunflower’s small group (A) was teacher directed and didactic but included problem solving, high level questioning, and collaboration. Three different lessons focusing on the properties of circles as stipulated by the school district’s geometry curriculum map were taught during the study. The first lesson required students to discover how pi was determined by using string to compare the circumferences and diameters of circular objects. The
students also invented the area formula for circles by dividing a cut out paper circle into sectors and rearranged the sectors to create a parallelogram. The lesson extended geometry standards taught in the seventh grade that required students to use formulas to find the area of circles by additionally requiring the students to make an “informal argument for the formulas” (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2011, p. 78). The second lesson during the study required students to develop the formula for finding the area and arc length of a sector after finding the area and lengths of equal sectors in a fictional garden problem. For the third lesson, the students measured and compared the radii of concentric circles and the arc length created by an inscribed angle to discover and prove that circles were mathematically similar. At the end of lessons two and three, Ms. Sunflower projected the corresponding KA exercises to further familiarize the students with the KA program.

*Khan Academy station.* The KA group (station B) of students used laptop computers to complete a task list (playlist) of assignments that were due each week (See Appendix J for the two weekly playlists). The playlist for the first week of the study reviewed standards taught the week prior to the study. The assigned KA exercise modules for the first week were: “Area of Triangles;” “Area of Parallelograms;” “Area of Trapezoids;” and, “Area of Composite Figures.” The KA exercise module titles for the second week of the study were: “Radius, Diameter, and Circumference;” “Area of Circle;” “Arc Measure;” “Angles in Circles;” “Areas of Circles and Sectors;” and, “Arc Length.” The students recorded their progress on each module on a hardcopy of the playlist that was kept in their mathematics binders. When finished with their playlist, the KA students could work on their projects.
The KA program notified the students as they progressed through five levels: “Struggling;” “Practiced;” “Level 1;” “Level 2;” and, “Mastered.” The students received 8 points for each module in which they were assessed as “Practiced,” 12 points for “Level 1,” 14 points for “Level 2,” and 16 points for “Mastery.” The maximum number of points students received for completing the playlist was 50. We assigned the playlist such that students would have some choice in which modules they completed and how much time they dedicated to each module.

**Project group station.** The PBL project design followed Solomon’s (2003) model which required projects to be open-ended, real-world, and collaborative. The students in station C worked on a project that required them to design, construct, and analyze a dartboard game target comprised of at least three concentric circles divided into at least five equal sectors. Their targets were to be drawn on unlined standard white copy paper. The project required students to apply the knowledge they acquired in the two weeks of the study; however, understandings from the first session of the teacher’s group were not prerequisite skills needed for the first session of work on the project. The first session of the project group required the students to read and discuss the overall expectations of the project, look at example targets from various sports, construct their circular targets using a compass, protractor, and straightedge, and calculate the areas of each concentric circle in their target. The first two groups of students who worked on the project seemed to be unaffected by having not yet worked in the teacher’s group.

On the additional two project days, students were expected to calculate arc lengths and ring and sector areas and assign proportionally appropriate game point values to the sections within their dart target. The students were permitted to determine their own groups because we felt the groups were already heterogeneous, and the students should have some choice in who
they would work with on their project assignment. Partners were required to create and analyze identical target designs. Ultimately, most of the students chose not to work in groups or with a consistent partner because of the difficulties they experienced when using the compasses and the protractors as they attempted to construct duplicate target designs. Most of the students informally assisted each other rather than working together as partners on the same project. (The struggles displayed by some of the students while working on the project and student collaboration were further explained and examined in Chapter 4 of this study.)

A project checklist that specified tasks to be completed during each of the three class periods and the point values of each task was also provided (See Appendix I for the project handout). Each task on the checklist had a space for a teacher (me) to initial indicating completion. Ms. Jones, Ms. Sunflower, and I decided the checklist was needed to keep the students on track while working on the ongoing project. The decision was based on our collective previous experiences working on long-term projects with students where the students had difficulty maintaining stamina to complete a task when the reward (final grade) would not be received for several weeks. Additionally, the English Language Arts teacher on the ninth-grade team regularly used checklists that outlined daily task completion expectations for projects; the students were already familiar with the strategy.

Data Collection

Observations, student and teacher pre- and post- interviews, and student pre- and post-surveys were the sources of data for this study. The pre- surveys and pre- interview data were collected during the week of March 7, 2016. The study’s blended learning Station Rotation instructional strategy began on Monday, March 14 and continued through Friday, April 8 for a total duration of two weeks or ten school days; the study was interrupted for two weeks while the
school district observed a week of spring break and for one week of Jackson school’s project-based full day intercession courses. The post- surveys and post- interviews were collected during the week of April 11, 2016.

During class sessions, I observed student-to-student discourse, student engagement, student and teacher utterances, student-to-student interactions, student-to-teacher discourse and interactions, and the overall atmosphere of the blended learning environment. Observations were handwritten daily field notes and voice memos left on my cell phone which were typed and added to an electronic document. I had hoped to video record students, but video recording was prohibited by the school district’s Department of Performance and Accountability office. The video recordings would have been used to observe student behaviors and engagement. Ten of the 11 assented and consented students completed a written pre- and post- survey and pre- and post- interviews (See Appendix K for the survey and Appendix L for the interview protocols). Wenas Nachos did not complete the post- interview. She expressed disinterest by putting her head down when I called students out of the classroom one by one to be interviewed in another room. On a second day of interviewing, she again put her head down and turned her face towards the side wall. I did not prod her to complete the survey. She later told me that she was having a bad week due to some personal issues and was in a foul mood on both days. Rey Ren said he was not interested in being interviewed; no reason was given. He shook his head indicating he did not want to participate when asked to leave the classroom for both interviews, but he did complete the pre- and post- written survey.

**Interviews.** The pre- and post- interview questions enabled me to describe the impacts of blended learning with KA and PBL on the students’ attitudes towards mathematics and their motivations to do mathematics. The teacher’s interviews shed light on her perceptions of the
study. The interviews followed Merriam’s (2009) semi-structured format and were guided by the pre-determined questions but departed from the questions to further explore the students’ and teacher’s experiences. The planned interview questions were used flexibly to allow me to delve deeply into how the students felt about the use of projects, working in small groups, KA’s modules and its points and badges system, computer assisted learning, and to gain insight into their mathematics confidence.

The student interviews ranged from about 13 minutes in length to about 27 minutes and were conducted during the school day in a private room one-on-one to facilitate candor. None of the interviews were ended prematurely due to the school’s class period schedule, but about five of the pre- interviews and four of the post- interviews extended beyond the scheduled class time causing me to become mildly anxious. I completed these interviews more quickly and may not have given the students adequate time to respond to the questions. The preliminary open-ended student interview questions listed below (See Appendix L for the interview protocols) are subdivided by the research questions they addressed, but several of the questions aligned to multiple research questions:

1. Research question: How does blended learning with KA impact student intrinsic motivation to do mathematics?
   a. How old are you? What grade are you in?
   b. How did you like math last school year? Did you get to talk to your friends?
   c. What was the best thing that happened in math class last semester? Was math ever fun last semester? What was the worst?
   d. Do you like math? Why or why not?
   e. Are you good at math? How do you know?
f. Are some people born better at math? Can anyone be good at math if they work hard?

g. Do you know what you want to do as a career when you grow up? Why? Would you consider working in a job in a STEM field?

h. What projects have you done in math classes in the past? Which project was your favorite? What did you learn? Do you like doing projects? Do projects make you like math class more?

i. Do you feel like you get more help when the teacher teaches the whole class or when the teacher works with a small group of students? Which do you like better: working in a small group or working with the whole class? Should your teacher do more small group work in class? Does it make students like math more or less? Why?

j. Do you prefer to learn on your own, with a small group, or with the whole class? Why?

k. Do you ever do extra problems on KA that were not on your playlist?

2. Research question: What are student perceptions and attitudes towards instruction that is blended with KA?

a. Do you prefer to practice doing math on the computer or with the entire class?

b. If you were a math teacher, what percent of class time would your students work on the computer? What percent of class time would be spent teaching the old-fashioned way on the board? Why?

c. If you could, how would you improve your current math class?
d. If you were the principal, would you make all the math teachers use computers and projects to teach math?

3. Research question: How are student feelings of competence, relatedness, and autonomy impacted by blended learning with the use of KA?
   a. When working on the computer, do you ever help or get help from your classmates? Do you think talking to your classmates helps you to like math better?
   b. Do you like working by yourself on KA?
   c. Does KA make you feel like you are better at doing math? Why or why not?
   d. Do you think the other kids know how well you are doing on KA? Do you care if other kids know what topics you have mastered?
   e. Do you feel smarter in math this year than last year? Why or why not?

4. Research question: What particular features of KA impact student motivation to do mathematics?
   a. Have you used a computer program to learn math before this year? Which one? How do you like it?
   b. Did it allow you to collect points or badges? If so, do you like them? Do they make you want to do more math to earn more points and badges?
   c. When you get a point do you feel like you know more math? When you get a badge do you feel like you know more math?
   d. Do you watch the KA videos if you don’t understand something? How often?
   e. What are your favorite kinds of problems: multiple choice, fill in the blanks, or the kind when you have to move something?
f. Do you ever do extra problems on KA that were not on your playlist?

g. How would you improve the KA website if you could?

The pre- and post- interview questions were slightly modified to reflect the pre- and post-
conditions of the study. The purpose of the post- interview questions was to give insight into
how the students’ perceptions and feelings about mathematics were impacted, if at all, by the
changed learning environment. The interviews were audio recorded and transcribed. The pre-
interviews took place within one week of the start of the study, and the post- interviews occurred
within three days of the conclusion of the study.

The teacher, Ms. Sunflower, was interviewed pre- and post- the study (See Appendix L
for the interview protocols). Her pre- interview took place two school days prior to the start of
the study, and her post- interview took place on the Friday (five school days) after the study
concluded. I conducted both interviews after school in Mrs. Sunflower’s classroom. The
interviews were about 20 minutes in duration and were audio recorded and transcribed. The
teacher was interviewed to determine her pre-existing teaching style and to give voice to her
existing and post perceptions of KA, PBL, and blended learning.

The open-ended teacher interview questions listed below are subdivided by the research
questions they addressed, but several of the questions aligned to multiple research questions:

1. How is student intrinsic motivation to do mathematics impacted by blended learning
   with KA and PBL?

   a. Why did you decide to become a teacher?

   b. What is your area of licensure?

   c. What is your teaching experience? How long have you taught? What subjects?

   What types of settings have you taught in?
d. Do you enjoy teaching? Why or why not?

e. Do you currently use KA? Do you think it does/can help students to learn mathematics?

f. Do you think the blended learning instructional model used for the study is sustainable with only one teacher in the classroom? Explain. Are there any strategies that you might continue to use?

g. How would you describe PBL? What is it? Do you currently use it? What are the pros and cons of using it? If so, how often? Why or why not? About how many projects do your students do in a year? Would you like to do more? Less? Do you think it does/can help students to learn mathematics? Do you think it motivates students to learn? Why or why not?

2. What are student perceptions and attitudes towards instruction that is blended with KA and PBL?

   a. Does KA make students feel more confident in their abilities to do mathematics?

   b. How would you describe the term blended learning? What is it? Do you currently use it? Why or why not? What are the pros and cons of using it? Do you think it does/can help students to learn mathematics?

   c. If you had a magic wand and could create a perfect setting for teaching, what type of teaching style would you have? Would you lecture? Use nature to teach? Combine mathematics with science? The sky is the limit. What would you do?

3. How are student feelings of competence, relatedness, and autonomy impacted by blended learning with the use of KA and PBL?

   a. What do you think motivates children to learn mathematics?
b. What is the best way to teach mathematics?

c. Do your students like math? About what percent would you say love it? Like it? Hate it?

4. What particular features of KA impact student motivation to do mathematics?
   a. Do you think blended learning motivates students to learn?
   b. Do you think KA motivates students to learn? Explain.
   c. What do you think motivates children to learn mathematics?

The teacher’s post-interview was modified to include questions on specific components of KA such as the “Mastery Challenges” that assess a broad set of topics, student responses to their ability to choose the topics they would work on from their KA playlist, and which topics students chose to attempt to reach the highest levels of mastery. The teacher was asked if she thought the students attempted the “Mastery Challenges” on their own or if prodding was required. She was also asked if students preferred reaching the lower two levels of KA’s mastery system (“Practiced” and “Level 1”) in multiple topics or achieving the “Mastery” level in a few topics since either choice could result in receiving the maximum numbers of points for the playlist. The questions inquired about how and why she believed students made these decisions and her perceptions of how the students’ decisions impacted their confidence and motivations to do mathematics. Additionally, in the post-interview the teacher was questioned on her perceptions of the Station Rotation model. She was asked about her observations and opinions of the model’s impact on student engagement, student agency, assignment completion rates, the students’ persistence in doing mathematics, how and if the model could be implemented in other mathematics classrooms, and what advice she would give to future teachers using the model. All interviews were transcribed by a professional transcription service into electronic Word documents.
**Written surveys.** The consented and assented students completed the written survey whole group in a quiet room. The pre- survey was conducted on the Tuesday before the study began, and the post- survey was given on the Monday after the conclusion of the study. The survey questions included the essential questions (See Appendix K for the written survey) from the list of student interview questions because I anticipated that there may not have been sufficient time, space, and opportunity to conduct uninterrupted interviews with each of the 34 students in the class. The essential questions were determined by their relevance to the research questions. Because only 11 students were assented and consented, I was able to conduct all the individual interviews; however, the written survey also served as a backup means of collecting consistent data. The written survey provided an opportunity for students who may not have wanted to speak freely to me in an interview to express themselves and ensured that all the same questions were asked to each participant.

**Data Analysis**

The data collected during this study were analyzed following Merriam’s qualitative data analysis approach (2009). I continuously reviewed the purpose of my study which was to illuminate the impacts of blended learning with KA and PBL on student motivation and the research questions as each piece of data was being collected (Merriam). Merriam stated, “Data that have been analyzed while being collected are both parsimonious and illuminating” (Merriam, 2009, p. 171). As tentative themes emerged in each stage of data collection, I wrote memos to myself, added more in-depth questions to the interviews, and made focused observations on those themes at each subsequent stage of data collection.

The *constant comparative method* was used for analysis (Corbin, Strauss, & Strauss, 2008, p. 30). The survey and interview data were analyzed and coded as they were collected to
capture meaning as it arose. I began with open coding (Merriam, 2009, p. 178). All possible themes were considered as I reviewed the students’ pre-survey and pre-interview data. An Excel spreadsheet was used to record and display the data for analysis. The four research questions were used as primary column headings, and the seven survey questions were used as subheadings for the relevant research question. Each column was subdivided into pre- and post-columns. Responses for each participant on the survey and interview questions (including direct quotes, paraphrases, and my interpretations of the participant’s views) were categorized by their relevance to each research question and were recorded in a row of the spreadsheet. Highlighting and bolded font were used to emphasize poignant and particularly illuminating responses. Patterns and recurring themes were identified. The emerging themes were combined and narrowed to address the research questions (Merriam).

Chapter Four

The initial themes that emerged from the data informed the post-student and teacher interviews and the classroom observations. The fourth chapter of this dissertation discusses limitations of this study, the initial and final themes that emerged from the set of data, and how each theme was determined. The data are divided into pre-conceptions, observations during implementation, and post-conceptions. Patterns among the data are examined and explained.

Confidentiality

Confidentiality was maintained throughout the study. The students created their own pseudonyms to be used on the written surveys and in the interviews. The pseudonyms along with the students’ month and day of birth were recorded on the written surveys. The month and day of birth were recorded on the surveys to ensure the pre- and post-surveys could be matched
if a student forgot his or her pseudonym. The audio-recorded interviews were destroyed once transcribed.
Chapter 4: Findings

“Just don't talk all the time. You have to use your resources...Just keep on doing the rotation thing. I'm really feeling that.” Adrianna, post- interview

My professional experiences as a mathematics educator provided me with countless observations of children who were simply bored and frustrated with traditional whole group one-size-fits-all mathematics instruction. I believed the advent of adaptive online tutorial technology and its use as a tool for blended learning might impact mathematics education by enabling instruction to be more individualized and stimulating. My belief was the result of experiences where the students appeared to benefit academically and affectively from working in smaller groups and from working with technology. In this study I investigated blended learning’s impact on student attitudes towards mathematics; I sought to explain the effects of using blended learning with Khan Academy (KA) and Project Based Learning (PBL) as an instructional strategy to give insight into how teachers might inspire students to enjoy and persist in learning and doing mathematics. The potential of blended learning with adaptive online tutorial KA and PBL to influence student motivation and attitudes towards learning mathematics is illuminated.

In the first section I describe the limitations of the study. Observations of the students’ agency and their initial introduction to KA before the study began are presented in the second and third sections. The fourth section examines themes from the participants’ pre- interviews and surveys. The fifth section, the largest section of the chapter, explores the final themes gleaned from the data. Detected changes in the participants’ perceptions and views are included. The final themes are divided by the three components of the Station Rotation model: the teacher station, KA, and the project station. The participants’ overall impressions of the Station Rotation model are also examined. The data are frequently presented with first person direct quotes and
accompanying interpretations. The direct quotes are used to convey the participants’ “own sense of reality” in their own voices to substantiate and clarify my interpretations of their experiences (Yin, 2014, p. 113). The research questions were:

1. How is student intrinsic motivation to do mathematics impacted by blended learning with KA and PBL?
2. What are student perceptions and attitudes towards instruction that is blended with KA and PBL?
3. How are student feelings of competence, relatedness, and autonomy impacted by blended learning with the use of KA and PBL?
4. What particular features of KA impact student motivation to do mathematics?

Limitations

This study was limited by several circumstances. There were 11 student participants from one class. Eight were girls, and three were boys. The participant group was not economically, racially, and possibly intellectually diverse since no students with Individualized Education Plans were included. A larger and more varied sample may have generated different or more illuminating results.

African American and poor. The class and the participant group were poor and predominately African American. The Jackson School served 91% African American students and 4% White students. Ten participants were African American. One of the participants was White. The U.S. Department of Commerce (2014) noted that in 2012, African Americans were the least likely of any subgroup to have a home computer (67%) in comparison to whites (82%), Hispanic (69%), Asian American (87%), and Native American (68%). African Americans and Native Americans were also the least likely to have Broadband Internet at home (61% and 56%
respectively) behind Whites (77%), Asian Americans (84%), and Hispanics (63%) (U.S. Department of Commerce, National Telecommunications & Information Administration (NTIA)). Because most of the participants were African American, they were less likely than the general population to have both high-speed Internet service and computers at home. Economic information was not collected on the participants, but presumably all the participants were economically disadvantaged because 99.5% of the students at Jackson School were economically disadvantaged. In an evaluation of nearly 10,000 public schools, Judge, Puckett, and Cabuk (2004) found that “children attending higher poverty schools had significantly fewer computers and software programs available” (p. 383). Schools serving students with low socioeconomic status often hired less technical support staff, and the teachers were less professionally developed on the use of the computers in comparison to schools that served students with higher socioeconomic statuses (Warschauer, Matuñiak, Pinkard, & Gadsden, 2010). By 2016 forty-eight percent of children living in poverty had access to high-speed Internet at home, and 33% of children living in poverty only had Internet access with a mobile device like a smartphone (Rideout & Katz, 2016).

Because the participants were predominately African American and were presumably economically disadvantaged, they may have had limited computer and Internet access both at school and at home. Curt mentioned (without prompting) that he did not have a computer at home in both his pre-survey and post-interview. When asked if KA’s point and badges system made him want to do more mathematics, he explained that he and others did not have time to do more or extra mathematics on KA because “some don’t have a computer at home.” Adrianna and Ann Marie also mentioned they did not have computers at home. The idea of doing more mathematics than what was required by the teacher was inconceivable due to their limited access
to computers outside of class time. At least three of the 11 participants did not have home access to a computer. The participants may have had less overall experience with technology in comparison to children who were not economically disadvantaged. The possible lack of access and exposure to the Internet and a home computer may have impacted the participants’ opinions of computer-based blended learning; unfortunately, there is little extant research on African Americans or the impacts of poverty on learners’ attitudes towards blended learning (Okwumabua, Walker, Hu, & Watson, 2011) to substantiate this possibility. Nevertheless, a more racially and economically diverse sample of participants may have yielded different results.

**Struggling students and students with identified disabilities.** The class selected by Ms. Sunflower did not contain any students with identified disabilities; therefore, none of the participants had identified disabilities. One student, Vanessa, said she had dyslexia, but she did not receive special education services. A relatively high number of students at Jackson School received special education services due to an identified intellectual (cognitive or learning) disability or physical disability (25%) in comparison to the national rate of 13% and the state percentage of 14.8% (Ed.gov, 2015). The participating group of students did not reflect the state, national, or the school’s proportions of students with disabilities.

Blended learning has been touted for its flexibility and its potential to address unique learning needs (Means et al., 2010; Staker et al., 2012; Thompson, 2011); however, “For the struggling learner and those with disabilities, perception of flexibility often does not translate to reality” (Smith & Harvey, 2014). Smith and Harvey’s (2014) study posited that KA was not suitable for struggling learners because they believed it was not aligned to the Universal Design for Learning (UDL) principles outlined in the UDL framework. The UDL framework provided a
means for assessing the accessibility of curricular materials for learners with disabilities and cultural differences (Smith, 2016).

The framework was used to assess KA for the presence of a variety of features including the ability to adjust the visual display, alternatives for visual displays and hearing the program, the accentuation of key concepts, opportunities for users to collaborate and create goals, learning supports aligned to different levels of difficulty, user choice, language assistance (like definitions for vocabulary and symbols), and an environment with minimal distractions (Smith & Harvey, 2014). The study concluded that KA satisfied little of the criterion on the framework and was consequently not aligned to the principles of UDL; the KA program was posited to be “limited in providing critical features and embedded supports…with language, literacy, and executive function deficits, hallmarks of challenges associated with students of disabilities” (p. 236). The study did not explain the misaligned features of KA in detail or give insight into how KA could be improved to align to UDL. It is worth noting that KA underwent a major overhaul in the fall of 2013 which is within a year of the study’s publication date; Smith and Harvey (2014) stated that at least two of the assessed features, hierarchal content aligned to grade-levels and goal setting, were added to KA after their study was completed. Additionally, a follow-up report published by Smith (2016), the lead author of the first study, stated that the videos on KA were aligned to the UDL principles but his second publication did not analyze the entire KA program as the previous study had. In either case, students with disabilities may have had different perceptions of KA due to accessibility and other characteristics of the program. Had the participant group included students with identified disabilities, the findings may have been different.
My role as mentor, researcher, and teacher. The study was also limited by my multifaceted involvement as the teacher’s mentor, researcher, and my role as a co-teacher before and during the implementation of the study. Prior to the study, as the teacher’s mentor, I co-taught with Ms. Sunflower about two class periods per month from August to November and about once per week in December through March. I sometimes led or modeled instructing the students while Ms. Sunflower circulated in the classroom assisting students. At other times, Ms. Sunflower led instruction while I circulated and assisted students. When the study began, I knew all the students in the class by name. I believed the students treated me like any other teacher in the building.

My relationship with the participants may have impacted their truthfulness and my questioning during the interviews. Reflexivity, mutual influence, may have occurred (Yin, 2014). The participants might have responded in the interviews and while being observed in ways that they thought might please me or Ms. Sunflower. The participants were aware that Ms. Sunflower and I had a friendly yet professional relationship. During Miyaa’s pre-interview she made a generalized recommendation that mathematics teachers should “talk less and let the students talk more” and then immediately stopped talking and visibly winced. She expressed a concern that her comment might upset Ms. Sunflower. She said, “I didn’t want to say [pause] that’s mean.” I reminded her of the confidentiality statement and that the broader purpose of the study was to improve mathematics instruction; I explained the study was not specifically about Ms. Sunflower. Miyaa agreed to continue the interview but wanted to make sure that Ms. Sunflower would not read or listen to the interview and think she was talking specifically about her. She was worried about hurting Ms. Sunflower’s feelings. Given Miyaa’s concern, she and the other participants may have spoken more candidly had I not had a known relationship with
Ms. Sunflower. Despite the confidentiality statements in their assent and consent forms and the reminder of confidentiality made in each interview, they might have thought I would share their comments and identities with Ms. Sunflower. I also might have asked more probing questions had I not personally known the students. My prior knowledge of and my existing relationships with the students may have redirected my questioning.

Additionally, while conducting this study, I inwardly hoped the data would be positive and would show that student motivation was positively impacted by blended learning with KA and PBL. The study may have been affected by my personal bias. My affect, verbal language, inflection, body language, and other means of communication during the study may have conveyed this hope to the participants and could have influenced their responses and my interpretations of their responses. A researcher who was unknown to the students and had fewer interactions with both the students and the teacher may have shown different results.

My role as both researcher and teacher in the study might also have affected my ability to collect the available pertinent data during the study. At times, it was difficult to lead a group of students while simultaneously recording student utterances and taking notes. Additionally, the 11 participants were dispersed between the three Station Rotation groups because Ms. Sunflower and I believed assigning them to one group would have disrupted the learning environment. Assigning the participants to one section of the seating arrangement would have required all the students to receive new seat assignments for the two-week study. Separating the participants from the non-participants might have caused the students to think the two groups received different treatment or instruction. Ms. Sunflower and I decided the benefits of isolating the participants in one group did not outweigh the potential disruption and other possible negative impacts. Had the participants been assigned to one rotation group, observation data may have
been easier to collect. In my efforts to simultaneously teach and record data, important data could have been overlooked or excluded.

The teacher’s position as a first-year teacher with an assigned mentor from a college program was another extenuating circumstance. Many teachers do not have another credentialed teacher who is available to co-teach and lead small groups. By happenstance, a university student assisted on the first day of the study allowing for a significantly smaller student-to-adult ratio. The senior high school students at Jackson School had one-to-one computing. The students had access to laptop computers in all their core classes. This accessibility enabled us to implement the blended learning instructional strategy; a lack of one-to-one computers might adversely impact other teachers in their implementation. An empty classroom in the building was used to subdivide the class of students into two smaller and more manageable groups. Using the second classroom eased congestion and limited noise and distractions. Some teachers may not have daily access to an empty classroom and may be restricted to one classroom for instruction. The conditions of the study might be difficult for a typical teacher to replicate.

An additional limitation was the participants’ mixed willingness and abilities to communicate their opinions both in writing and verbally. Some participants were very talkative and spoke with standard English while others said very little or were difficult to understand due to their use of non-standard English. Adrianna, Demarkus, Vanessa, Miyaa, and Ann Marie were vocal, easily understood, and had strong opinions while Curt, Maya, and Wenas Nachos sometimes limited their responses to a few words even when asked to expand. It was sometimes difficult to comprehend statements made by Curt and Judy due to syntax errors and their use of colloquialisms, and Wenas Nachos and Rey Ren chose not to participate in some of the data collection. Judy was absent for about three days of the two-week study. Her absences affected
her KA usage time and may have impacted her perceptions of the study. The variation in the quality and amount of data from the observations, interviews, and survey responses challenged my abilities to consider each participant’s perceptions equally when creating an overall analysis of the group’s data.

**Learned Helplessness**

Earlier in the year, I noticed some of the students’ reliance on the teacher. Some students raised their hands for assistance from the teacher within seconds of reading the mathematics exercises or problems they were asked to solve. They did not seek help from their classmates, refer to their notes or the textbook, or attempt to solve the assignments on their own before requesting assistance. These students would wait until the teacher or another adult in the classroom could assist them before attacking a mathematics task. There were occasionally visitors from City University and other adult visitors in the classroom. At least one student called out the teacher’s name at least once every few minutes while working on mathematics to request assistance. Students asked questions like, “Is this right? I just want to know if I set this up right.” Once assistance was rendered, the student might ask or even politely demand to know if their final answer was correct. At times, while the teacher was busy or was working with a student and was unable to reach a student whose hand was raised (or calling out to the teacher), the student in need might disengage from the instructional activity by putting his or her head down, exclaim that he or she was not getting help, and would sometimes yell out that no work would be done until help was received. Some called out comments like, “I’m not doing anything else until you help me” or “You’re not helping me so I can’t do this.”

At least some students seemed to exhibit *learned helplessness* – a self-defeating sense of powerlessness and incapability that occurs after a failure (Diener & Dweck, 1978). Ms.
Sunflower and I planned to combat our speculation of the students’ dependence on assistance from an adult by using verbal statements to encourage the students to work collaboratively and to persist. We informed the students that we would not provide step-by-step explicit instructions on how to solve any mathematics exercises and problems; they would need to work collaboratively with their classmates to decompose problems, refer to their notes, and use other resources. We also explained that providing step-by-step instructions for doing mathematics stifled their learning. Ms. Sunflower and I strategically began using probing questions to help guide the students’ mathematical thinking when they were stuck on a problem or exercise. We hoped our actions would promote student agency over time.

**Introduction to Khan Academy**

Ms. Sunflower decided to use KA as preparation for the first semester exam for two back-to-back (block) class periods once per week in December, a few months before the study began. Because KA was a district approved instructional program, she felt the students should begin using it to review previously taught topics. Although, possibly not directly related to the study questions, it is worth mentioning that Ms. Sunflower reported that her students had difficulty logging into the laptops and into KA in their first week of usage. The school district assigned all high school students usernames, passwords, and Google student email accounts to be used with various district recommended Google products like the learning management system (LMS) Google Classroom or document sharing with Google Documents. The username and passwords were required to log in to (essentially turning on) the district’s secured laptops prior to logging in to any program. The KA program recommended that students log in to KA with their Google school email accounts rather than personal email accounts because using the school email accounts enabled the school district and the teacher to access and store usage data.
Ms. Sunflower planned to have the students log in to KA for the first time on a day that I was not able to be present. She and I reviewed the process of having the students to log in the first time in an after school meeting the week prior to the students’ initial introduction to KA; we anticipated that the process would be smooth and uneventful. We expected the high school students to have already memorized their student email addresses and their log in information from their usage of the laptop computers in their other classes from August until December. Most of the students’ passwords were their eight-digit birthdates. The usernames were typically an abbreviated form of the students’ full names along with about four numerals.

Ms. Sunflower later told me that none of her students had memorized or previously recorded their school log in information. She supplied the email addresses and passwords to all the students. This single experience informed me and Ms. Sunflower that the students had likely not used the laptop computers as often or as extensively as we presumed. I was present the second week (and second time) the students used KA. A few students needed my assistance logging in on the program. I asked several students if they used their Google student email accounts for any of their other courses. The students replied unanimously that they had not used their Google email accounts prior to their initial log in with Ms. Sunflower in the previous week. There was one girl who had recently enrolled at Jackson School who was not able to log in to KA with my assistance or with assistance from the other students because her Google email address had not yet been created in the district’s enrollment database (PowerSchool). Ms. Sunflower and I concluded that the students might need ongoing assistance with proficiently using the laptop computers due to their limited prior exposure to the laptops.

The students were asked to bring headphones to listen to the KA instructional videos. About 20% of the students brought headphones each day. To accommodate this supply shortage,
we allowed (and encouraged) students to listen to the videos out loud. During class periods when all the students were working on KA, typically one or two KA instructional videos were playing aloud. The peripheral sounds did not seem to be distracting. A written playlist that included a checklist of several KA geometry transformation exercise sets was assigned each week. I noticed that some students had difficulty making the two finger motions on the laptop touch pad that were required to do many of the geometry translation and reflection exercises. The exercises might ask the students to slide or rotate a polygon drawn on a coordinate graph a certain number of degrees. Some students were initially frustrated by the finger dexterity needed to translate figures with the laptop touch pad, but within about two weeks most seemed to have mastered the necessary two finger movements. The students were expected to complete their weekly playlist by Thursday of the next week. Ms. Sunflower wanted the students to have a weekend to complete the weekly playlists in case they needed to visit the public library or stay after school to gain access to a computer and the Internet. Each weekly playlist typically included 5 or 6 KA exercise sets.

Ms. Sunflower and I emphasized the use of KA’s videos because previous studies warned that the students may rely on the teacher if given the opportunity, and the students might infrequently watch the videos if not required (Murphy et al., 2014a; Murphy et al., 2014b; Wiginton, 2013). As the students began working on their first KA geometry transformation exercise sets in December, we made comments like, “I love the way the two of you are working together” or “I see you talking to your partner about math. That’s great.” We asked questions like, “Did you ask your partner before asking me? Who did you ask?” The students sometimes smiled in response to our verbal acknowledgements. We continuously encouraged students to collaborate and watch the videos if help was needed. I also verbally acknowledged any badges I
noticed being earned to individual students. If a student earned a badge I often congratulated the student saying, “Oh, I see you have a new badge. What was it for? Wow! What did you do to get it?” As the students were working, I might stop a student and ask to see his or her badges on their KA profile webpage. I would say something like, “Oh, I see you have a persistence badge.” Ms. Sunflower and I consciously decided to occasionally acknowledge badges with individual students but decided not to announce badges to the entire class. We did not display the students’ total energy points or badges because we felt public acknowledgement would transform the potentially intrinsic and personal recognition to a competition or performance reward.

Within the first sessions of working on KA, Adrianna closed her laptop, frowned, yelled out “I give up,” and put her head down. I asked her to not give up, and reminded her that many things were challenging, and she should keep trying. To my surprise, Adrianna opened the laptop and began working. A few minutes later, she yelled out “I finally got five and got the badge!” She smiled and giggled a little. I smiled at her and said, “I told you you could do it.” She had answered five problems in a row correctly. This experience with Adrianna was repeated with several students in the first few weeks of using KA. The KA requirement of answering consecutive exercises (typically five) correctly to achieve the mastery notification was immediately spurned by the students. The students often verbally expressed disdain for having to get a specific number of exercises correct consecutively rather than in totality.

Themes from the Pre- Written Surveys and Interviews

The written pre- surveys (See Appendix K) were the first data to be collected for the study. The pre- interviews were conducted within a few days of the written pre- surveys. Both were collected before the study began to give insight on the participants’ pre- existing attitudes.
and perceptions. The data were reviewed to determine some possible themes related to the research questions.

Table 3

*Views on Mathematics and Khan Academy*

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Can anyone be good at math?</th>
<th>KA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrianna</td>
<td>“Yes, because if they try harder they could do anything that they put their mind to it.”</td>
<td>“… [Points and badges] don't make me feel no type a way because I don't like KA…[but] Sometimes the points and badges make me want to do more math.”</td>
</tr>
<tr>
<td></td>
<td>“I was always good at it… I can teach other people things that they don’t know”</td>
<td>“…The stuff that's on there, it’s harder than our teacher telling us or look[ing] at it in the book.”</td>
</tr>
<tr>
<td>Ann Marie</td>
<td>“Yes…math doesn't get easier, it get harder in a way to the point you want to give up.”</td>
<td>“I don't like KA because I don't understand it and things I have not learned yet are on there.”</td>
</tr>
<tr>
<td>Curt</td>
<td>He explained that anyone could be good at math and poor performance was because, “They choose not to work hard to learn math.” “… I'm able to process math pretty well.”</td>
<td>“I can get to the assignments. Click and I'm on the assignment page, but to do the questions, the questions don't pop up. Just a blank.”</td>
</tr>
<tr>
<td>Demarkus Johnson</td>
<td>“…If you work hard to understand it, it would be easy.”</td>
<td>“…It [points and badges] make me feel like I accomplish something... make me feel like, “Oh, I really understand this.” I accomplished it, I understand it. It makes me want to do more stuff.” KA is “less stressful...at your own pace.”</td>
</tr>
<tr>
<td></td>
<td>“… [Some people] probably understand it or learn it more quicker.”</td>
<td></td>
</tr>
<tr>
<td>Judy Crane</td>
<td>“Anything is possible if you work hard…”</td>
<td>“Really irritating and stressing...Collecting points for my effort would make me want to do more math.”</td>
</tr>
<tr>
<td>Pseudonym</td>
<td>Can anyone be good at math?</td>
<td>KA</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------</td>
<td>----</td>
</tr>
</tbody>
</table>
| Maya      | “…With the right teachers and with good explanations…” | “I like learning math directly from the teacher because I really pay attention…”  
|           |                            | “They [points and badges] make me feel like I achieved something.”  
|           |                            | “I would make the explanations [on KA] seem simpler.” |
| Miyaa     | “I've always been good at math, it was [emphasized was] my favorite subject.” But now, “It's difficult, too difficult.” | “…The assignments are different from what we learn in class.” “I’d take off the levels, I wouldn't make it, you have to get this many in a row.” |
| Rey Ren   | “Yes, because once you get all the steps done and learned you remember it and it becomes easy.” | “[Energy points] Make me feel like I'm working hard…” KA would be improved if it were to, “Have prizes if you reach a certain level.” |
| Steph     | “Yes, because all they have to do is pay attention and do their work.” | “… Some of the problems are difficult, and I can't get three in a row correct.” |
| Curry     |                                          |                                           |
| Vanessa   | “If they really want to be good at math, you got to study for it, work hard for it, … have patience with it. You can't just be like, "I'm going to be good at math," and not do anything to work towards that. You got to put in the effort.” | “KA is hard. I'd rather do book work than KA… [The teacher] teaches us something, we'll get on KA, but it won't be the same way that the video teaches us. It'll be two different ways…” |
| Briggs    |                                          |                                           |
| Wenas     | “…Just put forth good effort and energy then anything is possible.” “I'm not good at math, but I like taking math…I like to learn something new that I didn't know before…I don't know. Math has never been a good subject for me.” | Dislikes KA, “It's because, say you get to your last one [exercise] and it'll be like, “Do three in a row” and then you get the last one right, you put the number in and it'll say it's wrong…so you have to start all the way over.” |
| Nachos    |                                          |                                           |

**Hard work equals success.** A prominent early theme was that most or perhaps all the participants connected effort and attitude to mathematics achievement in their pre-interviews and
pre-surveys. When asked if anyone could be good at math if they worked hard Steph Curry said, “Yes, because all they have to do is pay attention and do their work.” Adrianna similarly said, “Yes, because if they try harder they could do anything that they put their mind to,” and Ann Marie concurred by stating, “Whatever you do, put your mind to it, you can do it.” All the students indicated a belief that anyone could be good at math with focus and exertion. The participants appeared to exhibit growth mindsets; in other words, they believed that achievement in mathematics was not due to an innate talent but was attributed to effort and hard work (Blackwell et al., 2007; Dweck, 2006; Dweck, 2007). The belief that achievement and intelligence were malleable was found to lead to future academic risk taking, challenge acceptance, persistence, higher grades, motivation, and an increased achievement trajectory (Blackwell et al., 2007). Further, the belief that one can control his or her academic destiny was posited to result in less maladaptive feelings of helplessness (Blackwell et al., 2007; Dweck & Leggett, 1988). Although the student participants largely exhibited indications of the growth mindset, at least a few participants appeared to have a combination of both growth and fixed mindsets.

Demarkus, Maya, and Ann Marie’s beliefs included at least some fixed beliefs. They were the only participants who expressed the belief that some people were born better at math despite their statements that anyone could be good at math with tenacity. The belief that some people were born with a talent for doing mathematics was associated with fixed mindset beliefs (Blackwell et al., 2007; Dweck, 2007). When asked if some people were naturally better at doing mathematics Demarkus said, “They probably understand it or learn it more quicker. The way the teacher teaching it, they understand it that way.” But she went on to describe how anyone could be successful by saying, “You would have to really focus on it and really understand it. You can’t just like ... If she [the teacher] say, ”Anybody have questions?” Don't
be scared to ask questions, just ask them and try to get the topic. Then the more you learn, the
more you can do.” When asked the same question, Ann Marie also believed some of her
classmates were born better at doing mathematics and believed their speed at doing mathematics
to be a sign of greater understanding. She said, “Some people are more brighter at math than
others; like they get it instantly.” Although these three participants believed that some were born
better at math, as demonstrated by their speed at doing mathematics, they attributed success at
doing mathematics with hard work and dedication. For all the student participants, the ability to
do mathematics was not perceived as a gift or skill that was only attainable for some who were
privileged to be born with mathematical talent. This early finding misaligned to Dweck’s (2006)
research on how most people believed mathematics achievement was attained.

Dweck’s (2006) mindset research asserted that only 40% of the general American
population had growth mindset beliefs, 40% had fixed mindset beliefs, and the remaining 20%
held a combination of the two. Most people do not wholly attribute success in doing
mathematics to effort (Dweck, 2006). A consideration for explaining the disparity between the
participants’ and the general population might have been the potential impact of the school
district’s Mindset (2006) initiative espoused in the weekly advisory period mindset lessons, the
school’s culture, and the growth mindset lessons conducted by me and Ms. Sunflower prior to
the collection of study data. The students might also have answered the questions about their
potential to do mathematics affirmatively because their mindset training made them aware of the
answers we were hoping to receive. Regardless of the underlying reasons, I found the students’
beliefs on the origins of mathematics achievement to be significant at the onset of the study;
however, this finding contradicted the learned helplessness that was observed in some student
behaviors before the study began.
Small groups, projects, and computer-based instruction. The pre-surveys and pre-interviews yielded insight on the participants’ preferences for various instructional strategies. The participants’ responses to questions on whether instruction should occur in small groups, with projects, whole group, and/or with the use of computers showed some commonalities. All the participants preferred small group work to whole-class instruction. Most said they enjoyed working on projects and working in small groups because they were permitted to talk to and thereby learn from and teach their peers about mathematics. One participant, Adrianna, voiced sentiments about collaborative small group project work that were echoed by other participants.

Adrianna said mathematics was her favorite class during the school year of the study because, “I was always good at it…I can teach other people things that they don’t know.” When referring to mathematics class in the previous school year she said, “It [online tutorial ALEKS®] was boring, and that’s what we did every day. I personally like the teacher to talk to us instead of us getting on the computer all the time.” However, she did not prefer teacher-led instruction for the full class period from her statements, “You can’t keep talking to a kid for long because they start dozing off or going out,” and “…I love group projects because I don’t like listening to the teacher all the time.” Teacher-led instruction was preferred over using the online tutorial program in isolation for the entire class period, but small group activities and projects and engaging in collaborative discourse while working with an online tutorial program were preferred over teacher-led instruction. Adrianna said talking to other students during class time was prohibited in the previous year. She expressed favor for the group activities and projects she completed thus far in the school year by saying, “It make me feel like I can help people out when they need help…you can work with other people…and…get to know them better, and use other peoples’ sources [knowledge] to help…” She explained, “…We can ask each other…for help
[rather] than just asking the teacher.” In her opinion, student-to-student collaboration should also occur when working on computer-based instruction, “…It’s better to learn it from your classmates and your teacher. They can help you and you’re not just going to be doing that on a computer by yourself.” Adrianna thought student-to-student discourse and teaching other students were an integral part of learning. Her responses centered on the two strategies. Whenever she was asked for her perceptions of the instructional approaches used in mathematics class during the school year of the study and in the previous school year, her opinions directly correlated to the teachers’ permissiveness of student-to-student discourse during the learning process.

Demarkus, Curt, Miyaa, and Wenas shared Adrianna’s appreciation for the novelty of projects and the ability to verbally collaborate with their peers. Demarkus also cited opportunities for physical movement as a reason for enjoying working on mathematics projects. She said, “…It [projects] actually makes me like math more because it's not just silent work. Most the times we get to get partners and stuff. We get to move around and stuff, but if we just doing a regular assignment we got to be quiet and stuff like that. With the project when we in partners we get to see what they know, they knowledge plus our knowledge...we learn different things from them.” She saw collaborative work as a means of increasing her understanding of mathematics. Curt said, “They [projects] make me feel like it [is] fun. We just not doing worksheets and KA,” and “We get to be with friends.” Wenas also found small group work and working on projects to be beneficial from her responses, “It makes me feel better. For some reason…having things like a project makes it easier to learn and get the concept,” and “It's hands on. I get to learn from other people. Say, there's something I didn't know, for a certain problem, they would teach me something that I didn't know.”
According to Dejarnette (2014), students working in small groups to solve mathematics problems sometimes alternate asking and answering questions to each other and challenge each other’s thinking. The participants saw the back and forth contributions between themselves and their partner(s) as a means of building understanding. They felt their gaps and strengths in mathematics skills and understanding were merged with their partners during discourse to efficiently build understanding in a low stress environment. Miyaa added the opportunity for thinking critically as her justification for favoring project assignments. She said, “It [project] makes me excited…It makes me think more,” and “I like…there’s different steps and you have to go through it, when you go through it you have to think about, like wait, if I…[do] this then it wouldn’t make sense for the next step…” She explained the compounding effects of each decision made while working on a project and how solving non-routine problems excited her. At least seven of the 11 participants believed the alternative explanations they received from their classmates in their small-group discussions when working on projects or daily problems and exercises enhanced their mathematics sense-making and understanding. Four of the 11 participants, Steph, Vanessa, Ann Marie, and Maya communicated disfavor, ambivalence, or contingent favor for working on projects.

Ann Marie spoke positively of working in small groups with her classmates, “…You can help each other and get different people. It’s like brains working together…” But she did not like working on projects. She said, “Sometimes I choose to leave class when it’s going on because I don’t enjoy it [projects], and it’s hard. Even when I use my head, I still get lost, like, get confused and stuff,” but “With a group of people, it makes it less difficult.” She explained that during project work time, she sometimes tried to leave the classroom by asking to go to the bathroom or to her locker in the hallway. She disliked the ambiguity of projects and preferred
more straight-forward tasks that included explicit written or verbal instructions from the teacher. She was frustrated by the idea of diving into solving a problem or exercise without clear guidance because she was not confident in her ability to do mathematics on her own.

Steph only liked doing projects that included both individual and group accountability. He recommended that, “Each person got their own thing to do. Then they all put them together on a poster or something.” Ideally projects would include individual work that was combined in some way to create a final product. He thought projects should include both individual and group accountability, “Because people work at different speeds” he said. Researchers in an eighth-grade science inquiry study observed an increase in student engagement and discourse when student groups submitted a shared electronic Google Slide for a lab assignment (Koenig, Zydney, Behr, & Bao, 2017). Increased performance was observed with the individual and group accountability of the shared lab Google Slide (Koenig et al.).

As with Steph, Vanessa’s perceptions were impacted by the work habits of the students within her group. “I like doing projects. It just depends on … what group of people I have in my group,” she said. Vanessa expressed concern that students worked at different speeds and had different work ethics. She felt that working with only one partner more fairly divided the workload because when groups contained four students she and another student usually did the work, yet all four students often received the same grade. Her opinions of small groups and project work were dependent on her number of partners and the work ethics of her partners.

Maya was undecided on whether she liked projects. As with Ann Marie, she was uneasy with the open-ended nature of doing project assignments. She said, “It [projects] doesn't make [me] feel great because I always have to ask for help on almost every step.” She explained how she felt she rarely knew how to attack the questions or problems asked in projects on her
own and relied on the teacher or her classmates for constant assistance. Maya was not confident in her ability to do novel mathematics problems or exercises independently. Contrarily, Judy said “…Working on projects is my favorite of all things….” Judy agreed with Maya and Ann Marie that project instructions should be more “descriptive,” but she said projects made her feel “Confident, I work well with others and I like to teach my peers new things,” and “We work together to find the answer to the problems.” Judy’s enjoyment of projects was predicated on the ability to work in small groups or with a partner and said she did not like working alone on any project. Her confidence to solve problems was dependent on the teacher’s allowance of student-to-student discourse; she did not feel confident when working independently. For Ann Marie, Judy, and Maya, their mathematics self-efficacy was directly related to their ability to receive detailed instructions or to collaborate with at least one peer.

The Khan Academy program. The pre-data indicated several participants felt the KA program was too difficult, should provide hints without penalty, and did not like the feature that required users to answer three to five consecutive exercises correctly to advance to the next level. Ann Marie said, “I don’t like KA because I don’t understand it, and things I have not learned are on there.” Miyaa echoed Ann Marie’s opinion when she said to improve KA she would, “Make it EASY!” and elaborated by saying, “I’d take off the levels. I wouldn’t make it [so] you have to get this many in a row.” Steph said, “…Some of the problems are difficult, and I can’t get three in a row correct.” Demarkus said, “If you don't get the correct answer don't take away checks just keep giving problems like them [examples].” She wanted KA to provide detailed examples that were similar to the exercises she was asked to solve. Judy preferred to learn from the teacher rather than working on KA. She said, “I like learning math directly from the teacher because I really pay attention…get the direct message, and I’m more open to getting my
questions answered.” She appreciated her two-way interactions with the teacher and the teacher’s ability to immediately answer questions. Judy elaborated on why she disliked KA, “It makes me feel like I’m getting dumber actually…” She explained that KA’s points and badges system was “Really irritating and stressing!” And, “I get easily frustrated because at one moment I feel like I’m on a ball [sic] and then I miss the question or get it wrong.” The requirement to get consecutive answers correct to advance to the next level annoyed Judy, and she disliked the uncertainty of working on KA in comparison to the assurance she received from learning directly from the teacher. Adrianna agreed saying, “KA…It’s harder than our teacher telling us or look[ing] at it in the book.” She preferred demonstrations from her teacher to watching the KA videos or using the hint feature. This sentiment was repeated by other participants in the pre-data.

Vanessa disliked several KA features. Regarding the points and badges she said, “They make me mad because it’s hard to get them,” and, “…I always get the answer wrong. If you click the hint, you got to go back and do it again. If you always get the answer wrong…you’re just stuck on this one problem.” Vanessa felt KA should permit users to access the hints for solving the exercises and still receive credit for getting the correct response. She preferred straight-forward exercises. In her opinion, the exercises were too convoluted and difficult. “KA kind of makes me feel unsmart sometimes,” she said. Miyaa complained that, “…The [KA] assignments are different from what we learn in class…I’ve always been good at math, it WAS [emphasized was] my favorite subject,” but now, “It's difficult, too difficult.” As with Vanessa, Miyaa was frustrated by exercises that were not obviously similar in structure and used the same solution process as the exercises that were demonstrated by her teacher. Vanessa agreed with Miyaa in her conclusion that KA’s content seemed difficult because the strategies used to solve
the exercises varied from the teacher’s. She said, “Ms. Sunflower teaches us something [and] we'll get on Khan Academy, but it won't be the same way that the video teaches us. It'll be two different ways so we won't really know what it's talking about…” Learning from KA’s alternative explanations required her to watch KA’s instructional videos multiple times, “…When I don't understand it, I watch the video, and if I get it wrong I'll go back and watch it again, but I'll replay it a couple of times until I actually understand it,” she said.

Alternatively, Demarkus appreciated the explanations provided on KA. She said, “…She [the teacher] might be teaching it in a way where I don't understand it. It's just like different ways of teaching it. I might understand it more from the computer. Some people might understand it more from the computer.” Eight of the 11 participants, Ann Marie, Curt, Demarkus, Judy, Maya, Miyaa, Vanessa, and Wenas said they at least sometimes watched the KA videos for assistance. When Steph was asked why he did not watch the videos he said simply, “Cause I'm lazy.” Although Steph attributed his lack of watching the videos to laziness, I inferred that he and some other participants felt that completing the exercises (as required for their geometry course) was a more efficient use of their class time than watching videos. Further, none of the assigned KA problem sets introduced new skills; KA was used to review previously taught topics. Some students may not have felt that they needed additional instruction from the videos.

**Khan Academy versus other online tutorials.** Curt’s perception of KA was based on his previous experiences with another online tutorial program TenMarks. TenMarks, a product of the Amazon company, was commercially available to educators. It had both a free and a cost version and like KA it included both tutorial videos and a hint feature. On TenMarks, users accumulated virtual “coins” rather than energy points and could redeem the coins for gameplay
in the system’s built-in interactive games. The hints on TenMarks did not reveal the final answer for each exercise and could be accessed without penalty. The paid version of TenMarks was adaptive; teachers could assign exercises to individual students based on assessment data resulting in each student having his or her own learning path. When asked “How did you like math last school year?” Curt responded, “I liked it okay…Because we did math on the TenMarks.”

As with Curt, Miyaa and Maya made immediate references to the online tutorial ALEKS®, when asked the same question despite not being asked about other online tutorial programs or the specific technology they used in the previous school year. ALEKS®, a for pay program, did not include tutorial videos but did allow students to access hints to answer exercises. Maya said, “We did ALEKS® a lot. I liked it; it was pretty good.” Miyaa elaborated, “It [ALEKS®] was just easier [than KA] …If we didn't get it right, there was an example. An example tells you step by step and how to do the problem...Khan Academy has videos and when you mess up, you have to start all over. ALEKS®, if you messed up, they'll teach you how to do it, and then they'll give you practice.” The ALEKS® program included examples and links to an online textbook for each exercise for user support. The resources could be accessed without penalty; the solution was not marked incorrect if an assistance resource was accessed. Miyaa, Maya, and Curt believed ALEKS® and TenMarks programs to be more explicit. They felt the two programs gave hints and examples that explained the procedures for solving the exercises without penalties, and they only needed to substitute the numbers from the exercises into the example exercises to find the solutions. They considered explicit modeling of procedures to solve exercises to be ideal examples of teaching mathematics. Some of the interview and survey questions about KA yielded responses that compared KA’s format to ALEKS® and other online
tutorial programs. I hypothesized that the students’ instruction in the previous year formed a reference point for their interpretations of blended learning with KA in the current school year. Student comparisons of KA to other online tutorial programs they had previously used in mathematics classes became another initial theme.

**Khan Academy’s energy points and badges system.** Three participants were enthused by KA’s points and badges system before the study began. Maya said, “They [points and badges] make me feel like I achieved something…I like to see things add up sometimes…” She smiled in her pre-interview as she said, “I like the points and badges.” Rey Ren said, “[Energy points] Make me feel like I’m working hard.” Demarkus reverberated Rey Ren’s expression by stating, “It [points and badges] make me feel like I accomplish something…I feel like I did good or make me feel like, ‘Oh, I really understand this’ I accomplished it, I understand it. It makes me want to do more stuff.” Demarkus also discussed her points and badges with other students. She said, “I’ll be like, “Oh, I won this and then how much you win?”” Maya, Rey Ren, and Demarkus were incented to do mathematics by KA’s energy points and badges system.

The other participants reported either not noticing the points and badges or not caring about how many points and badges they earned. Adrianna initially said she did not care about the system, but then suggested that she found it somewhat motivating. Judy and Vanessa were annoyed by the system. Both said the rewards were too difficult to achieve. Ann Marie, Miyaa, Curt, Wenas Nachos, and Steph said they did not look at their energy points and badges and did not care about them.

Overall, student perceptions of the difficulty level of KA, the KA feature that required three to five consecutive questions to be answered correctly, and varied opinions on the points and badges system emerged as initial themes. Early on, most perceived the program to be too
difficult. The hint feature was considered to be a hindrance or penalty rather than a means of learning from one’s mistakes once an incorrect solution was submitted. Some participants expected uniformity in how their teacher and KA presented and solved exercises and were irritated by the perceived differences. They assessed the difficulty of KA based on its alignment to familiar procedures modeled by the teacher rather than on the cognitive demand that was required to correctly answer the mathematics exercises. Some also desired more detailed and unambiguous assistance than they received from KA’s instructional videos and hints. The participants felt that accessing the hints and examples should not disqualify their correct solutions preventing them from advancing to the next level.

Observations During Implementation

Pertinent participant behaviors were noted as the study began. As planned, I worked with group C (the project station) and half of group B (KA group) in a different available classroom while Ms. Sunflower led the teacher’s station group A and the remaining half of group B in her classroom. The students in my two groups left the classroom after completing and reviewing a projected daily warm-up activity. There were typically about 10 students in group C and about five students in half of group B. Ms. Sunflower and I assigned the group B students to one of our two classrooms based on the behavioral relationships of the students in the various groups each day. In other words, we deliberately chose which half of group B would stay with Ms. Sunflower or go with me based on their prior classroom behavior or their perceived abilities to harmoniously work in the same classroom as the other students in groups A and C. Because the composition of the groups changed daily due to the Station Rotation schedule and rare student absences, our decisions were often hurriedly made as the students arrived in the classroom and worked on their warm-up activity. By day four of the study, the participants sometimes called
out requests like “Pick me!” as Ms. Sunflower and I announced which group B students would stay or go with me to another room.

None of the students in my group verbally complained about going with me to a separate classroom. Ms. Sunflower and I discussed this positive behavior in our daily debriefings. I found it unusual that the students appeared to want to go with me and did not complain because I believed that my personality and classroom management style as a veteran educator was more stern than Ms. Sunflower’s. We speculated that the students liked the novelty of having mathematics class in a different environment and enjoyed walking down the hallway to the second classroom. Judy mentioned in her post-interview that leaving her normal mathematics classroom to have class in a different room was an exciting “big thing.”

A student observer from City University joined my group on the first day of the study. He assisted students as needed. His visits to Ms. Sunflower’s classroom were unplanned; we did not know in advance when he was coming. He was required to observe a teacher for 10 hours for an education course at City University but occasionally visited for additional hours beyond his course’s requirement. He visited somedays in between his classes at nearby City University. I explained the study to him before the study began on one of his visits.

The first round. The first round of implementation occurred over three school days on Monday, Tuesday, and half of the double class period on Wednesday. In three class periods that spanned over the three days, all of the students in the third period class (consequently all of the participants) cycled through the three stations A (teacher station), B (KA), and C (project) with each station lasting for most of one class period.

On the first day, the students picked up their three-ring mathematics binders (notebooks) that were stored in the back of the classroom and began working on two projected warm-up
exercises as they entered the classroom. The warm-up required students to find the area of a regular polygon from an illustration of a regular pentagon with one side marked as eight centimeters and a height marked as six centimeters. The second projected question asked students to draw an equiangular quadrilateral that was not equilateral. The students completed the warm up questions in their binders. Ms. Sunflower reviewed the solutions by writing on the board as she called on students to contribute responses. I circulated and assisted students by asking probing questions like, “What does it mean to find the area of a shape? How do you find the area of any shape?” The warm up took about eight minutes for the students to complete, review, and write corrections in their binders. Ms. Sunflower quickly reminded the students of the Station Rotation schedule that would be followed and how they would be divided into three groups based on their assigned seat. The rotation schedule was also posted prominently on a whiteboard on a side wall of the classroom. The students in section 3 gathered their belongings and went to the hallway to work in group C on their target project with me. Half of the students in the middle section of the classroom (group B) also joined my group.

We walked to an empty classroom down the hall from Ms. Sunflower’s classroom. I carried a small box containing the needed supplies: copies of the project instructions, extra copies of the weekly KA playlist, unlined white paper, compasses, rulers, protractors, and a few pencils. All the students brought a copy of their KA playlist and their mathematics binders where their class notes, assessments, and handouts were stored. The group C students chose their own seats and sat around two large tables. Five students from group B (KA) worked on the desktop computers that were along the wall in the rear of the classroom. The university student assisted the group B students as they logged into the desktop computers as I worked with group C. I reviewed the instructions, the project checklist, and the grading rubric with group C. The
students asked a few questions about the due date and how they would be graded and were given the opportunity to choose one or two partners to work with on the assignment. The group B students began working on the exercise sets on their playlist.

On the first day of the study, group C students were expected to construct a target and complete the first column of calculation of the Target Practice Table (see Appendix I). The target was to be comprised of at least three concentric circles and at least 5 equal sectors on unlined standard white copier paper. The smaller interior circle was the bullseye. The students were provided a compass, protractor, and a ruler to complete the constructions. Many seemed unfamiliar with the two types of compasses (the plastic Safe-T brand and the traditional model made of a metal pivot between a pencil and a pointer) and how they were used as indicated by their questions like, “How do you use this [compass]? I’ve seen this before but I don’t know what to do.” And “What do I do with this?” After noticing the students’ difficulties, I demonstrated the use of both compasses by drawing several concentric circles as an example. I asked the students, “How many degrees were in a circle?” and modeled using a protractor to measure angles. It was unclear how many students had a prior understanding of the use of a protractor.

I assisted students as needed as they constructed their concentric circles and divided the circles into equal sectors. Per the project’s written instructions, partners were required to construct identical dartboard targets. Ultimately, none of the participants who had decided to work with a partner were able to duplicate their partner’s concentric circles and sectors in the allotted class time. Several participants measured the radii of the circles in their partner’s target and attempted to use a compass to draw a duplicate target, but the compass opened or closed slightly resulting in circles with different dimensions. The partners held their targets side by side
or overlapped their papers and held them up to the light to compare them only to determine that none of the targets were the same. The participants experienced similar difficulties when dividing their targets into sectors using the protractors. About half of the group divided their targets into six equal sectors by using a ruler as a straightedge and determining the angles with estimation (eyeballing) and did not use the protractor. Most of the remaining half of the group used the protractor to divide the target into five equal sectors of 72 degrees.

In planning the project, Ms. Sunflower, Ms. Jones (the grade level intervention specialist teacher), and I did not anticipate that using a compass would be a barrier for project completion. We thought the students had previously used compasses because we thought they were a standard middle school tool; however, I later learned the CCSS for mathematics stipulated that students use tools to make geometric constructions in the seventh grade but did not specify the use of compasses until high school geometry (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2011). Protractor usage was specified in the fourth grade of the CCSS (National Governors Association Center for Best Practices & Council of Chief State School Officers). Had we realized the students had little or no exposure to compasses and seemingly protractors, we would have taught compass usage before beginning the project. The participants’ inability to duplicate their partner’s target resulted in an impromptu modification being made to the instructions of the assignment. We planned for the students to evaluate, compare, and analyze a single target per group of partners; but, instead I asked the students to answer the question in number five of the project based on their own target. Although all the students had different targets, they were encouraged to work together and check each other’s work. They were not assigned to a group. The participants seemed to gravitate
towards working with others who had divided their targets into the same number of sectors as they had, but none of the students worked in an identifiable work group or partnership.

Once the concentric circles and sectors were constructed, the students were to find the area of each ring section and the total area of the dart target. I assisted some students in using the ruler to measure the radii of each of their circles. Some participants called out questions like, “What do I do next?” and “Is this right?” throughout the lesson. I typically responded “Read the next row of the checklist. It tells you what to do next,” or “Did you ask your partner?” While I worked with the students working on the target project, the university student assisted the students in group B with logging on, doing the KA exercises, and troubleshooted with the videos because videos would not play on the Mac desktop computers. I later learned that the videos did not play because computers in the room we were using had not been updated with Flash® Player.

As the first class period of the study concluded, I signed off on the student checklist for each student who completed the dart target construction and the calculations in the first row of the Target Practice handout. I announced to the class, “Feel free to help your neighbor” to continue to promote student-to-student discourse and collaboration. I noticed that participants who were finished with their daily tasks on the checklist were helping other students rather than beginning the checklist tasks for the next day. I collected all of the students’ work at the end of the class period for safekeeping. We returned to the classroom. The observations made on the first day of the study were consistent on days two and three of the study as the remaining participants cycled through the project and KA stations. The university student did not visit again in the studied class period for the remainder of the study, but his presence on the first day allowed me to focus my attention solely on group C. Had he not been present, I would have had
to juggle the unanticipated assistance I provided with the measurement tools for group C with the assistance the group B students needed.

On days two and three, I noticed some of the participants working on KA appeared reluctant to use the hint feature because using the built-in hints resulted in the exercise being marked as incorrect. When I suggested that a stuck participant use a hint, he or she might say “No, then it won’t count,” or “You get an x for using the hints!” The participants consistently complained about the penalty for using the hint feature in their pre-data and during the study when asked to access a KA exercise hint when assistance was needed. After the first day of the study, I used Ms. Jones’ full size classroom rather than the classroom used on the first day. I selected the first classroom because it contained about ten desktop computers; since realizing the KA videos did not play on the computers, I used Ms. Jones’ classroom and had the KA students to bring their assigned laptop computers. The Flash® Player was updated on the desktop computers about one week later, but I continued to use Ms. Jones’ room as the room with the desktop computers was sometimes unavailable. Each following day, Ms. Sunflower and I called the group B students to check out their laptop computers from the secured computer cart while the class worked on the warm-up activity. Although we developed a routine, checking out and then checking in group B’s laptops each period consumed at least about three to four minutes of class time. Some time was wasted because the small furniture-filled classroom forced students to walk along the perimeter of the classroom to reach the laptop cart. The laptops were kept on a locked cart, and the school required students to write their initials on an inventory form to sign out and sign in the laptops for each use in each class period. Each student was assigned a unique laptop number on each teacher’s cart. Students were not permitted to use another student’s laptop without express permission from a teacher. The student laptop computers also had to be
Ms. Sunflower and I debriefed each day. On the first day of the Station Rotations, Ms. Sunflower smiled and commented that she enjoyed having time to actually assist students in need. She felt she was unable to provide the assistance some students needed prior to the study. She said that several of the students in her groups commented about how they “really learned today.” She reiterated this remark in every debriefing during the study.

**Mastery learning.** All of the participants rotated through the three stations by the second class period (of the double-period) on Wednesday of the first week of the study. Ms. Sunflower and I reviewed the students’ composite progress data available on KA’s dashboard on the Saturday after the first week of the study. We used the data to plan the teacher’s (group A) small group instruction and modified the class’ KA assignments based on their previous progress. However, we did not use the individual student data or make individual KA playlists for each student as recommended (Cargile & Harkness, 2014; Cargile, 2015). Khan’s (2012) recommended *mastery learning* did not occur when the participants used KA or in the teacher’s small group. According to Khan, the founder of KA, *mastery learning* was the bedrock of his vision for using the KA program (2012). Khan said, “Mastery learning simply suggests that students should adequately comprehend a given concept before being expected to understand a more advanced one” (Khan, 2012, p. 37). The students were assigned primarily grade level topics on KA regardless of their existing knowledge, and the students in the teacher’s small group were not required to master a topic before moving on to the next topic.

KA has a diagnostic assessment that can be assigned to provide students with differentiated exercises at their individual achievement level, but Ms. Sunflower and I did not
use the KA feature. The diagnostic pre-assessment would have directed students to varied learning paths at different grade levels that were not necessarily aligned to the district’s geometry curriculum. In our meeting prior to the beginning of the study, Ms. Sunflower and I discussed how the KA data could logistically be used as a tool for mastery learning. We decided to informally observe student progress on KA during class time and to review the data in depth in our Saturday lesson planning meeting. Neither of us felt we could review the data in depth or make modifications to the existing lesson plans based on student progress during the school week for several practical reasons. Ms. Sunflower was unable to meet before or after school because she supervised students after school for various activities like tutoring and clubs and had meetings before school; further had she and I found the time to meet, if we discovered there was a topic that should be re-taught, the district’s geometry curriculum calendar did not provide time for re-teaching. Topics had to be continuously introduced to stay current on the calendar’s recommended schedule. Khan’s version of mastery learning was incompatible with the school district’s requirements.

We decided our version of mastery learning would occur through the selection of warm up activities and the reassignment of KA exercise sets in the second week of the study that addressed any topics the students struggled with during the first week of the study. When a KA set was reassigned, students were given an additional week to work on the topic. The students also created their own learning plan from the choices they made on their playlists. The students struggled with finding the area of sectors in the first week; therefore, four sector area problems were included in the warm ups for the second week. None of the participants had reached Level 1, 2, or the Mastered level in the KA dashboard for the Area of Composite Figures module that
was on the playlist on the week before the study began; consequently, the module was added to the playlist for the first week of the study.

Our version of re-teaching was determined by our anecdotal observations as the students worked on the target project in the project station, in Ms. Sunflower’s teacher station, and from the KA dashboard progress data. We considered reorganizing the student groups in the second week based on the students’ progress data from the first week, but we both felt the students had already adjusted to the existing pattern of the rotations and thought disrupting the students’ routine might result in classroom management issues. Additionally, because three class periods were needed for each full cycle of rotations, grouping changes would need to have occurred after the third or sixth class periods to not interfere with the rotation schedule. We would have needed to reorganize the students in the middle of the block class period since the third and fourth class periods occurred on a Wednesday double-period class.

On the Monday of the second week we added a KA exercise demonstration to the lesson plan for Ms. Sunflower’s teacher station. A student volunteer logged into Ms. Sunflower’s computer. The KA problem of the students’ choice was projected, discussed whole class, and submitted. We made this addition to our instructional plan to expose students to the input format required for submitting answers on KA, and because we believed doing the demonstrations would boost the students’ confidence. We felt the students needed a confidence boost because some verbally complained of KA being too difficult. The students already seemed familiar with KA at the date the study began, but some appeared to have trouble with inputting responses in the proper format for some of the geometry questions. For example, some of the sector area KA exercises expected the answer to be input in terms of pi; the students sometimes used 3.14 as an
estimate for pi resulting in the exercise being marked incorrect. We predicted that doing a demonstration problem would prepare the students to work on the KA exercises.

Deploying mastery learning or using progress data to continuously modify instruction to address individual student learning needs proved challenging for me and Ms. Sunflower. We found that finding the time to plan modified instruction and the potential for classroom management disruption from fluidly reorganizing student groups based on individual progress data to be barriers; however, the most impactful obstacle for mastery learning was our adherence to the district’s recommended curriculum calendar. Following the calendar did not permit class time for individualized re-teaching or remediation of foundational skills.

**Khan Academy usage data.** The KA exercise sets assigned in the first week of the study were: Area of Triangles; Area of Parallelograms; Area of Trapezoids; Area of Kites (video only – no exercises), and Area of Composite Figures. The exercise sets for the second week were: Radius, Diameter, and Circumference; Area of Circle; Arc Measure; Angles in Circles; Areas of Circles and Sectors; and, Arc Length (see Appendix J for both playlists). Each playlist was worth a total of 50 points towards their course grade. Students received eight points for the Practiced level, 12 points for Level 1, 14 points for Level 2, and 16 points for reaching KA’s “Mastered” level. The scoring method gave the students choice of which exercise set to work on and which level to work towards for the desired grade.

The usage data were reported from the start of the study on Monday, March 14 to the Tuesday, April 12 due date of the playlist assigned in the second week of the study. Jackson School’s week of intercession activities (no regular classes) and a week of spring break (no school) occurred between class period five and six. The students were given the KA playlist for the second week in the fifth class period of the study (Friday). Ms. Sunflower and I hoped the
students with computer and Internet access at home might work on the assignment, but only two of the 11 participants worked on KA during the two weeks between class periods five and six. Miyaa worked on KA exercises for about four minutes, and Vanessa worked for on KA for about five minutes. The two participants worked on KA for a relatively short amount of time.

During the study, the students worked on KA for three class periods after a daily warm-up activity was completed and had the option to work on KA for a fourth period on the last day of the study. The Station Rotations concluded on April 8, but the students were given the weekend to complete the KA playlist assignments. The 11 participants were logged into KA for a total of 789 minutes. The average amount of time the participants were logged in was 71 minutes. Six hundred thirty-one minutes were spent by all the participants working on exercises and mastery challenges, and 35 minutes were spent watching videos. About 95% of the participants’ time was spent doing the exercises and challenges with little time being spent playing the instructional videos. Less time was spent viewing videos in this study than in the Research of the Use of Khan Academy in Schools (Murphy et al., 2014a) study where students played the videos for about 15% of their time on KA. Eighty-seven of the total log in minutes were times outside of school hours; 33 of the 87 minutes were spent by Adrianna beginning within five minutes of Jackson School’s dismissal time suggesting that she likely worked on a school computer. Several of the teachers on Ms. Sunflower’s grade-level team allowed and encouraged students to do homework for up to about 45 minutes after school each day in the teachers’ classrooms using the classroom desktop computers. Each classroom contained about four desktop computers. A total of 32 badges and 70,557 energy points were earned in the duration of the study.
### Table 4

*Time Spent on KA Exercise Sets and Points and Badges Earned 3-14-16 through 4-12-16*

<table>
<thead>
<tr>
<th>Name</th>
<th>Total</th>
<th>Videos</th>
<th>Exercises and Challenges</th>
<th>Badges</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrianna</td>
<td>85</td>
<td>3</td>
<td>77</td>
<td>1</td>
<td>4900</td>
</tr>
<tr>
<td>Ann Marie</td>
<td>29</td>
<td>0</td>
<td>26</td>
<td>0</td>
<td>2810</td>
</tr>
<tr>
<td>Curt</td>
<td>65</td>
<td>0</td>
<td>54</td>
<td>2</td>
<td>3645</td>
</tr>
<tr>
<td>Demarkus Johnson</td>
<td>52</td>
<td>1</td>
<td>39</td>
<td>1</td>
<td>3041</td>
</tr>
<tr>
<td>Judy Crane</td>
<td>39</td>
<td>2</td>
<td>33</td>
<td>1</td>
<td>2446</td>
</tr>
<tr>
<td>Maya</td>
<td>114</td>
<td>8</td>
<td>84</td>
<td>8</td>
<td>22513</td>
</tr>
<tr>
<td>Miyaa</td>
<td>75</td>
<td>0</td>
<td>60</td>
<td>2</td>
<td>4790</td>
</tr>
<tr>
<td>Rey Ren</td>
<td>62</td>
<td>8</td>
<td>49</td>
<td>7</td>
<td>6519</td>
</tr>
<tr>
<td>Steph Curry</td>
<td>78</td>
<td>0</td>
<td>67</td>
<td>5</td>
<td>7350</td>
</tr>
<tr>
<td>Vanessa Biggs</td>
<td>117</td>
<td>4</td>
<td>99</td>
<td>3</td>
<td>8045</td>
</tr>
<tr>
<td>Wenas Nachos</td>
<td>73</td>
<td>9</td>
<td>43</td>
<td>2</td>
<td>4528</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>789</strong></td>
<td><strong>87</strong></td>
<td><strong>35</strong></td>
<td><strong>631</strong></td>
<td><strong>32</strong></td>
</tr>
</tbody>
</table>

*Note.* All time was measured in minutes and rounded to the nearest minute. The Total time is the amount of time students were logged into the KA program. Exercises and Challenges is the time users spent actively working on the exercises and completing the Mastery Challenges. The points were energy points.
Table 5

*Levels of Achievement on KA Exercise Sets 3-14-16 through 4-12-16*

<table>
<thead>
<tr>
<th></th>
<th>Struggling</th>
<th>Needs Practice</th>
<th>Practiced</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Mastered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrianna</td>
<td>0</td>
<td>1</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ann Marie</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Curt</td>
<td>0</td>
<td>3</td>
<td>11</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Demarkus Johnson</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Judy Crane</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maya</td>
<td>2</td>
<td>12</td>
<td>8</td>
<td>4</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>Miyaa</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>5</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Rey Ren</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Steph Curry</td>
<td>2</td>
<td>19</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Vanessa Biggs</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Wenas Nachos</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**Post- Perceptions**

**Khan Academy station.** The impacts of the various components of the KA program, the usage data of specific participants, and the participants’ impressions of the blended learning instructional strategy are discussed in the next section of this study. The components include KA’s energy points and badges system, the KA playlist of exercise sets assigned by the teacher, the participants’ desire to talk to their classmates during KA work time, the participants’ choice to do unassigned KA exercises and the extra KA exercises they chose to do, and other topics that emerged during the interviews are explained. The discussion begins with the profiles of three participants. Two, Maya and Vanessa, stood out due to the amount of time they worked on the KA program and the third, Demarkus, was notable because her detailed remarks were
reverberated by other participants. Data from the remaining seven participants are discussed. Similarities and differences among the perceptions and usage of the participants are examined.

**Highest Users Maya and Vanessa.** Vanessa and Maya were logged in the highest amount of time of the participants with 117 and 114 minutes respectively. Although Vanessa and Maya spent roughly the same amount of time working on KA, their time was spent differently. Maya earned nearly three times the energy points and badges and reached the Mastered level for nearly four times the skills of Vanessa. Maya earned the highest number of energy points (22,513) of the participants during the study, and Vanessa earned the second highest (8,045). The median number of energy points (4,790) was earned by Miyaa. The lowest numbers of energy points were earned by Judy (2,446) and Ann Marie (2,810). Maya earned substantially more energy points than the other ten participants. Wenas Nachos was the only participant who played more videos than Maya; she played nine which was one more than Maya’s eight. At first glance, it appeared that Maya was the highest mathematics achiever of the participant group, but the energy points were earned for behaviors relating to persistence and exertion and not necessarily for submitting correct answers (Khan Academy, 2016). According to the KA glossary, energy points are:

A measure of effort on Khan Academy; points are awarded for various learning activities like practicing exercises, watching a video…as well as for exhibiting positive character strengths like asking and answering questions in the Khan Academy community. (Khan Academy, 2016, para. 6)

**Maya.** Maya was a soft-spoken student. During class time, she was typically on task and engaged during learning activities. Her disposition was friendly, and she talked with the other students at appropriate times during class. She described herself as being “average, not very
good, but average” in mathematics because she intermittently received “good grades.” She said she had to work to understand mathematical concepts and thought she did not do well on mathematics tests. “…I don’t really get the concept and I end up not really doing good on tests…,” she said. During the interviews, she was quiet and reserved. Her responses were one or two word answers for most questions, but she smiled and became animated and lively when we talked about KA’s energy points and badges.

Maya may have been intrinsically motivated to work on KA. She worked on the unassigned topics, she said, solely to earn energy points and badges and did not discuss her points, badges, or mastery challenge successes with her peers or anyone at home; however, she did say she tried to sneak peeks at her classmates’ points whenever she could to see if they had more or fewer points than her. She wanted the points for internal satisfaction and said she had not and had no future intentions of bragging to her classmates about her large amount of points. She watched the instructional videos to gain additional energy points and to learn, but she said learning was secondary to earning points.

Maya had a computer and Internet service at home which afforded her the opportunity to do the extra KA work she desired. The energy points and badges gave her a sense of accomplishment. In the post- interview she said, “I like the reward points and stuff that we get. It make you feel like you achieved something good.” She earned the KA badges “Picking Up Steam” three times, “Persistence” twice, “Geek of the Week: Practice,” “Going Transonic,” and “Geek of the Week: Mastery.” “Picking Up Steam” was awarded for accurately and quickly answering exercises, “Persistence” was awarded for continuing to work on a topic in which she had previously struggled, “Geek of the Week” badges were earned for completing five mastery challenges and five practice tasks in one week. The practice tasks “Going Transonic” was
awarded for accurately and quickly answering ten consecutive exercises. Two of Maya’s eight badges were earned for accuracy; six were earned for behaviors related to persistence. The fulfillment Maya received from attaining KA’s energy points and badges was conveyed in both her pre- and post- survey and interview responses. KA’s reward system motivated her to do more exercises than she might have done otherwise. When asked if the points and badges made her want to do more math in her post- survey she replied, “It make[s] me want to do more topics because I like to see the points and badges add up.”

Maya earned KA’s highest Mastered level for 29 sets of exercises during the study. She was at the levels Needs Practice or Practiced for the remaining assigned exercise sets. She reached Mastered for 21 more exercise sets than Miyaa’s and Vanessa’s eight Mastered exercise sets. Miyaa and Vanessa had the second highest number of Mastered sets. The median number of Mastered sets for the participant group was one. Five students did not reach the Mastered level for any sets during the study; the highest level achieved by Adrianna, Ann Marie, and Demarkus Johnson during the study was Practiced, and the highest level achieved by Curt and Judy Crane was Level 1. Maya reached the Mastered level for a substantial number of exercise sets relative to the other ten participants; however, most of her Mastered level notices were for elementary exercise sets. She worked on unassigned second through sixth grade mathematics and English Language Arts exercises with the titles: Simple Verb Aspect, Concrete and Abstract Nouns, Read Picture in Graphs, Distributive Property of Multiplication, Associative Property of Multiplication, Areas of Parallelograms, Add Using Groups of 10 and 100, 2 Step Word Problems, The Missing Number (Add and Subtract within 1000), Measure Lengths 2, Points on the Coordinate Plane, Find Perimeter by Counting Unit Squares, and various others. She chose to work English Language Arts although none of her teachers other than Ms. Sunflower required
her to use KA. She was the only participant who worked on another discipline during the study and was one of three participants who worked on unassigned mathematics exercises.

In addition to reaching Mastered for the most topics, Maya earned more energy points than Vanessa and the other participants because she worked on both elementary and the assigned topics while the others primarily worked only on the assigned topics. Although Maya reported that she worked on elementary skills to earn points and badges, I surmised that she worked on the elementary topics to fill learning gaps. Her higher number of Mastered sets, energy points, and badges reflected her perseverance and endurance rather than her attained grade-level skills. Maya was inspired by the personal working environment. She said, “I get to work at my own pace…” Self-pacing was important to her; she appreciated the ability to re-watch videos when needed and liked not having to keep up with a partner or the whole class when working on KA. The playlists provided opportunities for autonomy as she made personal decisions on which topics to do. She said, “I like the playlist instead of saying everybody do this one topic, because ... If she [teacher] did that, I probably wouldn't be able to do that one topic, because it'd be too hard or something.” Maya was not confident in her abilities and having choice in which topics she worked on inspired her to continue working.

Maya felt like KA was helping her to get better at doing mathematics. She cited the circle graph in her personal KA profile that filled as she progressed towards completing the exercises within the course as evidence of her improvement, “…They [KA] have the little pie [chart], percentage thing with how many, how much you've completed, and I have 20% of geometry completed…,” she said with excitement in her voice. The circle graph provided a concrete visual model of her learning and growth. Maya’s overall impression of KA was positive in her post- interview. Maya did not recommend any improvements for the KA website.
She felt the instructional videos helped her to learn new concepts, “He [Sal Khan] breaks down every little thing that, whatever the topic is, he breaks it down pretty easy to understand. I like that.” Her post-impression differed from her pre-data where she expressed a need for more detailed instructions and explicit direction from the KA videos. She expressed self-assurance in her post-data. She was more confident in her ability to successfully do mathematics on her own and with the assistance she received from KA through instructional videos and hints. Her post-data indicated increased satisfaction with the KA program.

Vanessa Biggs. Alternatively, Vanessa Biggs had a specific and extensive suggestion for improving the KA website in her pre- and post-surveys and interviews. Her personality was more outspoken than Maya. She had a lot to say and enjoyed being heard. Vanessa felt strongly that rather than including videos from the KA founder, Salman Khan, the website should include videos created by her teacher. “When I use Khan Academy, I watched the video, but the videos have a different way of teaching than what we have been learning. I don’t really understand what the person in the video is teaching because I learned it a different way…” She complained about being confused by the KA videos using different strategies than her teacher used in both the pre- and post-interviews; yet, Vanessa saw value in learning different methods to solve problems when she said, “…You know there is just more than one way to solve the problem.” She felt the alternate methods used by Khan to solve exercises required her to think to make sense of the two methods and therefore learn. Vanessa saw the instructional videos and hints on KA as actual learning tools for assistance but felt they complicated her learning experience by making her think more than she believed necessary when she connected the teacher’s strategies to Khan’s. She saw learning solely from the teacher as a more direct and efficient path to understanding and therefore felt she learned best straight from the teacher.
As with Maya, Vanessa cared about the amount of energy points and the badges she earned in her post-interview, but unlike Maya she did not care about them in her pre-interview. When Vanessa was asked if she looked at her energy points and badges in her pre-interview she replied, “Not really.” She did not begin to pay attention to her accumulating points and badges until the study occurred. Once she began to notice them, she did not discuss her earnings with her classmates because she felt it might possibly upset others who had fewer points or badges than her, but she did discuss them with her sister. For her, the badges represented the amount of time and work she dedicated to KA. She had previously mentioned during class that her parents encouraged her to work on KA when she had free time at home. When asked if she worked on KA at home and if her parents required her to work on KA, Vanessa said, “…Khan Academy is hard so I keep trying to do it so I can get my badges and do more mastery challenges. Most of the time, I do it on my own…” She worked on KA at home to earn more badges and believed the badges were a measure of her tenacity. Vanessa had access to both a computer and Internet service at home.

Unlike the apparent elation experienced by Maya, the points and badges caused at least some angst for Vanessa. In her post-survey Vanessa said, “They [points and badges] make me mad because I don’t get as much.” When asked if they made her want to do more math she replied,

Sometimes yeah, but if I ... I feel like you only get badges if you do so much work. If I keep doing the work, I keep getting badges. If I keep getting them wrong, it's like, what am I doing wrong to get the answers wrong? I don't usually get my badges. It takes a long time to get the badges if you keep getting answers wrong.
Vanessa’s desire to receive badges caused her to reflect and analyze her mathematical thinking after she submitted incorrect responses, but she also felt like the badges were difficult to achieve and did not always see them as inspiring as Maya did. Vanessa earned badges “Hang Ten,” “Nice Streak,” and “Great Streak.” The streak badges were earned for consecutively answering exercises correctly. “Hang Ten” was awarded for completing mastery challenges. Two of Vanessa’s badges were earned for accuracy; the third was earned for the persistence behavior of completing the optional mastery challenges.

**Demarkus Johnson.** Similar to Vanessa, Demarkus was outspoken in her interviews. She had a bubbly jovial personality; she smiled and giggled often as she gave detailed explanations of her impressions of KA. She seemed to enjoy vocalizing her opinions and was the most verbose of the participants. Demarkus worked on KA for 52 minutes (third lowest) during the study, earned 3,041 energy points (fourth lowest), did not work on KA outside of class time, and reached Practiced on six exercise sets and Needs Practice on one set. Her usage and performance on KA could be described as slightly below the median of the 11 participants.

Opposite of Vanessa, Demarkus expressed a preference for KA over instruction from the teacher due to the positive recognition she received, the novelty of using KA, and the understanding she gained from the academic conversations with her classmates. Demarkus said in her post-interview,

> You get awards and stuff on there, make it seem like you accomplish something; and, of course it's on a computer. We don't just have to sit down and listen to the teacher write stuff down. We get to use different technology and we get the, like, we like, “oh, I just got this badge,” and stuff like that.
When asked if she bragged to others about her points or badges she gave examples of what she said to classmates, “‘Like, oh girl, I just got this. Let me see your badges. Like, how many you got?’ It makes me want to do more, like, ‘I bet I could get more badges than you.’ Stuff like that.” She said she tried to figure out how many energy points or badges answering each exercise would yield and reviewed any incorrect solutions to learn from her mistakes so she could recover any energy points and badges she did not receive due to incorrect responses.

Demarkus expressed being motivated by the points and badges in her pre- and post- data. In addition to KA’s incentive system, she was also moved by student-to-student discourse. She preferred her ability to talk to her classmates while working on KA over her reported use of ALEKS® in the previous school year. She said,

> I think Khan Academy is better than ALEKS® because, like, we really didn't get no awards for ALEKS®. We ain't have something to motivate us and we didn't even, like, talk. We couldn't say, “Could you help me with this?” We had to raise our hands at the teacher. Stuff like that…And, [KA] got something to let us know that we doing good and we should keep going. That’s what the badge is doing on Khan Academy. It’s letting us know, like, you doing good. You getting good at this.

She saw the points and badges as immediate feedback and a cumulative measure of her learning, and she saw talking to her classmates as a necessary resource for learning. Raising her hand to wait for assistance from the teacher was undesirable in comparison to asking a peer for assistance. She thought waiting for help from the one teacher in the classroom and not being able to talk to her peers was an absurd use of class time. Demarkus said she usually did not understand the KA instructional videos and preferred asking a classmate for assistance because “…They use the same language in math that we understand.” She felt conversations with her
peers were more comprehensible than the instructional videos created by Khan. She said she received more help from her classmates than she gave to others when working on KA. In addition to the points and badges, Demarkus felt the autonomy she was allowed on the playlist inspired her to do more mathematics. When asked if teachers should give students a list of assignments rather than a playlist with choices, she replied,

    No, I think we should be able to choose because … We should be able to know what we good at and what we not good at. And we could pick something we good at. We could also pick something we bad at, and we can learn it from on there because it got hints and stuff on there and stuff like that; but, I think we like the computer better because it's not just what we been doing for, like, our middle school and stuff. But, we using computer now, we can do stuff on there, make us feel like we really doing something independent. And, when we get to do what we feel is best for us, do on the computer, like we get to pick, say, all righty, I can get on there if you'll accomplish this many on the list [playlist], on the Khan Academy paper, that we got to do. We don't got to start from this. We can go in any order we want.

Demarkus saw the opportunities for self-regulation and choice given on the playlist as privileges awarded to her and her classmates for advancing to high school. She believed working with her classmates empowered her to learn without direct assistance from the teacher unlike Vanessa who felt handicapped by her inability to work with a teacher while working on KA. For Demarkus, her new sense of independence increased her feelings of accomplishment.

**Remaining eight participants.** All of the participants who mentioned the playlist (Demarkus, Adrianna, Judy, and Maya) said the opportunity to decide the order of their work on the exercise sets and the levels they could achieve to earn their desired score moved them to do
more mathematics than they might have done had the teacher given them a rigid list of exercise sets to complete. Adrianna, Miyaa, and Judy also said they began with the exercise sets that they thought might be the easiest. For them, the ability to start with the least challenging exercises made them want to do more mathematics. Miyaa said that when she encountered a set that was too difficult she “moved to the next thing and did not fall behind.” Adrianna felt she was able to selectively build knowledge so that she could do harder problems with ease. She said,

It [the playlist] makes me want to do it more because some of them are easier than the other ones. If you start with the easy ones it will take you to the harder ones so you learn how to do it.

Judy concurred by saying,

I think the playlist is a better way because it gives the students a decision from [for] each assignment. If they don't want to do this assignment or if they feel it's too difficult at that time, they'll choose another one.

All three participants thought giving the students a list of exercises sets to do in a specific order would cause students to not want to work on KA because they thought the KA exercises were difficult and doing them in a specified order would cause students to give up when a challenging exercise was reached. Adrianna referred to the students’ need for autonomy by saying,

…Some students don’t like to be told what to do. When you just tell them to do something they might not want to do it because that’s not something they want to do, and all students want to have choices to either pick from here or there…

The participants felt that the playlist permitted them to drive their own learning as they made personal decisions within the confines of the teacher created playlist. All students received the same playlist, but each could choose an individual path for learning.
Judy mentioned that she liked the immediate feedback on the answers and being able to view her progress in real-time. She and Curt, without prompting, mentioned the importance of knowing immediately if answers were correct and how getting an immediate response made them want to continue working. Curt said, “We know that if we got the question right when we put it in and we don't have to wait forever.” He explained that knowing if he was answering the exercises correctly made him want to continue using the program. The participants preferred KA’s ability to quickly notify them of the rightness of their answers in comparison to assignments that had to be scored by the teacher. They knew instantaneously if they were successful on each exercise set. Miyaa spoke of being able to learn independently when desired. She said, “Khan Academy has videos you can watch if you do not understand, so it actually teaches you better than on the board [teacher]…You can always go back and not have to wait for the whole class…” She liked being able to learn on her own and at her own pace.

Most of the participants’ time on KA was spent working on the assigned exercise sets, and little time was spent working on extra exercise sets. Only two worked on unassigned topics as Maya did. Curt briefly worked on elementary and middle school topics such as Finding the Perimeter by Counting, Points on the Coordinate Squares, and Use Pythagorean Theorem to Find Right Triangle Side Lengths for about four of his 54 total minutes. Rey Ren worked on fourth grade Identify Rays, Lines, and Line Segment for about five of his 62 minutes. During class, both Rey Ren and Curt complained of having difficulty finding the assigned exercise sets on KA. The topics were assigned to students through KA’s coach recommendation feature, but the feature was new to KA and had glitches; the coach’s recommendations (assignments) did not display consistently on the students’ profile pages. Curt and Rey Ren may have accidentally worked on the unassigned topics.
**Khan Academy’s energy points and badges system.** The participants’ usage and post-perceptions of KA’s built-in points and badges system varied. Vanessa, Judy, Adrianna, and Miyaa’s opinions of the points and badges system changed from the pre- to the post-data. In Judy’s pre-interview, she said she liked mathematics class but did not like learning with online tutorial programs ALEKS® or KA. She said, “…I don't like to use technology when learning especially on math because it makes it difficult for myself. It makes me feel slow when I keep getting answers wrong…” She went on to describe how she struggled to correctly do the KA exercises and the program made her feel progressively “dumber,” but when asked about KA in her post-interview she smiled and made a facial expression of astonishment. I asked why she made the expression. She said, “…I’m surprised, because I never liked Khan Academy, but now it’s interesting to me because I can do well at it now, and I have more…Encouraging myself that I can do better.” She explained that her accumulation of energy points and badges were achievements that inspired her to do more mathematics. She called them “medals.” She discussed her “medals” with her friends and her mother. For her, the energy points and badges were visible achievements that served as evidence of her ability to do mathematics.

Adrianna was somewhat ambivalent in the pre-survey when she said, “… [Points and badges] don't make me feel no type a way because I don't like KA…[but] Sometimes the points and badges make me want to do more math.” But she was solidly inspired by the system in her post-data. She believed earning points and badges meant she was learning when she said, “I feel like I’m doing something right. I’m not just sitting there guessing. I’m really trying to get the answer. When I get badges, it makes me feel happy because I’m doing it right.” KA’s points and badges system led Adrianna to expend more effort to get correct solutions rather than
guessing at the solutions. Her ability to do mathematics (post-) was affirmed by the badges she received.

Miyaa was motivated by the points and badges to do mathematics after the study. She said, “I think it, but I do not say it out loud. I am proud of myself inside like “Whoa, I just did that, I just got a badge! I got my points…” Miyaa said that most of the time she kept her points and badges to herself, but she occasionally bragged out loud to one friend in the class which differed from her pre- interview when she said, “It [points and badges] doesn’t matter” and that she did not care about the system. She said she did not discuss or look at her points and badges before the study began. These four participants changed their opinions of KA’s built-in reward system from being indifferent or disinterested in the system before the study to being encouraged by the energy points and badges they earned after the study.

Maya, Demarkus, and Rey Ren were motivated by KA’s energy points and badges before and after the study. They were the only participants who expressed being motivated by the reward system in their pre- interviews and surveys. After the study, Rey Ren said the award system made him feel happy and made him want to do more mathematics. He said, “[KA] Makes me feel happy because my [avatar] character is leveling up…” Rey Ren was referring to KA’s feature that allowed users to change their personal avatar as they earn more energy points. The avatars became more colorful and detailed as points were accumulated. He was similarly positive about KA’s energy points and badges in his pre- survey when he said the points “make me feel like I’m working hard.” Maya, Demarkus, and Rey Ren’s positive perceptions of KA’s energy points and badges system were unchanged during the study.

Although the participants generally expressed positive feelings about the KA program’s energy points and badges and the playlists in their post- data, not all the participants shared
positive opinions of KA’s reward system. Curt, Steph, and Ann Marie consistently reported not caring or being incented by the energy points or badges in their pre- and post- data. Steph said pre- and post- that he did not look at his, did not care how many his classmates had, and never discussed them. Ann Marie said the system did not inspire her to do more mathematics and she never looked at them. In his post- interview, Curt said, “I don’t look at them, and I don’t much care about them.” Curt earned two badges (median was two) and 3,654 energy points, and reached Practiced or Level 1 in 12 sets earning him the perfect course grade scores for completing the playlists. Steph reached Mastered for six sets (third highest) and Practiced for seven also earning him the full grade scores for the playlists. Contrarily, Ann Marie was the lowest performer of the participants on KA. She worked on KA for the least amount of time (29 minutes) despite being present in class each day, reached the Practiced level or higher for 3 sets which was the least of all the participants, and earned the second least amount of energy points (2,810). The three did not have any obvious commonalities in their KA performance. Curt and Steph were high performers of the group while Ann Marie performed the lowest of the participants. Their disinterest in KA’s energy points and badges system did not seem to have a discernable impact on their performance.

**Recommendations to improve Khan Academy.** Several of the participants’ suggestions to improve KA made in their post- surveys and interviews reiterated the suggestions from their pre- surveys and interviews. Demarkus, Adrianna, Ann Marie, and Miyaa continued to feel that getting an answer incorrect caused them to receive a double penalty. An incorrect answer resulted in the initial dismay of receiving an “X” at the top of their webpage in the area that showed check marks for the set; they felt punished a second time by not being given credit for the exercises within the set that they had already answered correctly. KA required them to redo
the set of three or five exercises once one incorrect answer was submitted. Demarkus said to improve KA she would “…Not take away a check if you get a question wrong.” Demarkus felt incorrect answers canceled or reduced the value of her correct answers when she was required to redo a set. Ann Marie said she would, “…Stop making you start over after you get one wrong.” Miyaa agreed by writing on her post-survey, “I wouldn’t make them ‘Get Five in a Row.’ I would make it get ‘5 Questions Correct Total.’” She thought the program should require a specific number of correct answers, and the correct answers should not have to be consecutive. The KA program requirement to get a certain number of consecutive answers correct remained a nuisance for some participants.

Ann Marie also felt the exercises on KA were too difficult and preferred ALEKS® because she felt ALEKS® gave more explicit examples than KA. She said, “They [ALEKS®] gave good examples, and it wasn't as hard as it is with Khan Academy.” Ann Marie’s negative impression of KA was unchanged pre- and post-. Vanessa consistently wished the teacher was more involved in the KA program. In addition to suggesting that the teacher make the instructional videos herself, Vanessa said, “I would have the teachers put [a] note, comments, or helpful hints for when a student gets a question wrong.” Vanessa also continued to believe that the exercises on the KA program were too challenging.

Miyaa’s opinion changed over time. When Miyaa was asked if she previously liked KA in her post-interview she said,

No, because the way you have to get five in a row. Let's say I have four and I mess up on one, my last one, I have to start all over. Now it is just determination, I am determined to get all of them right in a row, which means I will put in more effort, and I will try hard just to get it right so I do not have to start over.
Miyaa, became accustomed to the challenge level of the exercises and the KA format and began to see her success on the program as a measure of her effort and persistence. Although she was still annoyed by the requirement to get consecutive answers correct to advance, she began to see how the requirement caused her to be more thoughtful in her submissions. Similarly, Adrianna initially said the KA exercises were too difficult and were harder than exercises that were typically assigned by her teacher. In her post-interview she said the KA exercises varied in difficulty, “Some of them are hard and some of them easy” and she could successfully (now) do the exercises with assistance from her peers. I surmise that the participants may have been less focused on the requirement to get consecutive exercises correct and the difficulty level in their post-interviews and surveys because, as with Vanessa, Miyaa, and Adrianna, they had become more comfortable with the rigor of the KA exercises and were more confident in their abilities to successfully do KA.

Steph and Adrianna felt KA should make the exercises more game like. They suggested that the exercises be integrated into interactive mathematics games that awarded energy points for correct answers. Maya, Curt, and Judy said the program was fine as it was.

Overall, the participants were inspired to persist at doing mathematics by collaborating verbally with their classmates, the choices they were afforded on the playlist, and most valued KA’s energy points and badges in their post-study data. The energy points and badges served as visible accomplishments and proof of the participants’ capabilities for learning. No two participants perceived the program in the same way, but they had a generally positive impression of KA. The participants preferred to attempt problems by using their prior knowledge to ascertain the best response through trial and error and asking a classmate. The instructional videos were used by some as a last resort means of receiving assistance. Some preferred the
expertise of the teacher to their classmates. Relatively little KA time was spent watching the videos and working on unassigned exercise sets.

**Teacher’s Station**

The participants’ perceptions of the teacher’s station were unanimous. All 11 spoke positively about working with Ms. Sunflower in the teacher’s station of the Station Rotation model of instruction. The participants said the instruction they received in the small group enabled them to get their questions answered, to get personalized attention from the teacher, and the instruction was a focused and faster in pace in comparison to mathematics instruction prior to the study.

Demarkus,

She broke it down into, like, stuff that we probably could understand. It's not just a whole bunch of words that we don't know or stuff like that. She'd give us, like, examples and pictures, and breaking it down, even though it still mean the same thing, or still have the same outcome. But it's like, easier getting broken down into steps..., it's only one of her and in a classroom, it's like a lot of us; but, if it's only a certain amount [of students], then she can get to all of us and all of our questions and stuff.

…It's probably easier for her to teach it as a whole class so she only got to say stuff once and everybody can hear her, and stuff. But, some people, they need more help. Like they need individual help, or with a small group, so they can really understand it. Some people learn faster than other people.

Miyaa,

The smaller group is better because it is quicker. I don’t know why, but it is quicker and you do not have people complaining… People can actually ask questions if we are
confused on what it [mathematics task] says. If it gives us an example and we do not understand, we can actually ask questions. When there is a whole class, there is so many kids we do not have time to ask questions.

Vanessa,

Well small groups, it's like when we're in a big group, it's loud. Everybody asks questions at the same time, but when we're in small groups, everybody can ask their questions without being talked over or they could just ask a bunch of questions without wasting time … but when you're in a big group, you can only answer so many.

Ann Marie,

I like small groups…Like she's [teacher] on the board telling us what we have to do, giving us examples and stuff. The computer doesn't do that.

Curt,

There's not as many people there; we can focus better.

The participants perceived the classroom environment in the smaller group to be conducive to learning. The teacher explained problems, did examples, and answered all the students’ questions. The participants believed that some students who did not ask questions during whole class instruction due to time constraints and competition for the teacher’s attention did ask questions in their smaller teacher’s station. The small group learning environment was perceived to have less distractions than whole group instruction, and the participants believed that more of their needs were addressed by the teacher. They reported that they and their classmates were not frustrated by having unanswered questions. All the participants emphasized the improved quality of instruction they received, and none mentioned that although they felt they received more attention, it was condensed into a shorter amount of time due to the rotation schedule. The
participants wholly preferred the teacher’s attention and the instruction they received in the teacher’s station for about one-third of class time to the whole group teacher’s instruction for the full class period that they received prior to the study.

Most of the participants’ positive responses focused on the teacher’s actions, but Adrianna’s centered on her classmates. Adrianna emphasized the peer tutoring she received in the teacher’s station. She felt her needs were addressed by her classmates.

Because you have other people to help you if you don't know the answer or you don't know what you're doing. You'll have people in that group that can help you and teach you how to do it and make you better at it. Me, I learn from listening to my classmates. I learn from my teacher, but I learn more listening to my classmates and that's how some kids might learn more better… Some of them are high class [high achievers] and they probably will know more than you do. They can teach you easy ways to get around the problem instead of doing it the hard way. If the teacher showed you a way, they can show you probably a way that's easier than how she did it.

I inferred that Adrianna and some other participants felt that student-to-student discussion was encouraged more often during the teacher’s station than in whole group instruction prior to the study due to the teacher’s need to manage student behavior. Adrianna preferred peer discussion over aid from the teacher. As stated by Demarkus, Adrianna felt her peers used a familiar language she could understand better than when the teacher explained something to her. She and Demarkus continuously expressed their needs for relatedness and how the need was satisfied in their small group discussions when working in the teacher’s station, working on the project, and on KA. The girls felt their reduced-sized groups of students developed a kinship in which they understood each other and could help each other to learn mathematics.
Some participants believed that they had more opportunity for student-to-student and student-to-teacher discussions in the smaller group during the study, but it is worth noting that the mathematics lessons they were taught were not vastly different than the lessons that were taught whole group prior to the study. The district’s required geometry textbook and curriculum calendar were used to plan both the whole group instruction prior to the study and the instruction in the teacher’s station during the study. Class time before and during the study began with a projected warm up exercise or problem on previously taught topics that was reviewed whole group before instruction on new topics began. The exercises and problems used during the study to teach newly introduced topics were selected from the district textbook and were supplemented with an activity from the National Council of Teachers of Mathematics’ online teachers’ resource Illuminations (https://illuminations.nctm.org/Lesson.aspx?id=1852) and a KA instructional video. Ms. Sunflower often supplemented the lessons from the textbook with additional resources to deepen student understanding with videos, activities, and problems before the study began. The exercises and problems from the textbook consumed the majority of instructional time both before and in the teacher’s station during the study. The primary difference before and during the study was the number of students in the learning environment. Adrianna, Ann Marie, Demarkus, and others who perceived the teacher’s instruction to be of a higher quality during the study may have thought so because they cited that they were more engaged and more able to get their questions answered. Overall, the teacher’s station was well received by the participants.

Project Station

The participants’ positive perceptions of the project station mirrored their perceptions of the teacher’s small group and their KA work. All participants spoke positively of their work in
the project station. Their comments centered on their abilities to peer-collaborate, get attention from a teacher (me) when needed, use measurement tools, and to get a break from listening to a teacher talk. They liked using the provided project checklist to monitor their progress. Some participants appreciated the modification that Ms. Sunflower and I made to the project allowing each student to create their own target design for their project and then collectively analyzing and answering questions about their designs; these participants expressed favor about their individual accountability and their final projects being challenging because they were different (various circle sizes) than their partner’s, and how this difference caused them to rely on each other more than if their targets had had the same dimensions.

Vanessa,

…I like that we had to do it on our own because if we had the exact same target, that means everybody would just be copying off of each other. I feel like we become more independent if we figure it out on our own and draw our own circles, figure out our own measurements. I feel like we became more independent by doing that because if we drew the exact same circle, we had the exact same answers, so nobody would really be putting in the effort to do the work. They would just be copying off of each other… because when we get to work on our own, it's like we get to work on our own pace…. Because some kids work faster. I know I work slow and fast at the same time, because sometimes my dyslexia messes with me. I work slow and fast at times, but when I do work fast, I want to work at my own pace so I don't just be stuck behind, waiting on people.

Adrianna,

Say if somebody wanted to check your target you already know the answer [to your own] so you can check their target because they're not going to have the same answer.
Maya,

People like to copy and not actually do their own work.

Vanessa, Adrianna, and Maya said working on their own target design made them want to do more mathematics. They, and some additional participants, felt that group projects sometimes resulted in an unfair distribution of work; some students did the work while others merely copied. Adrianna believed her mathematical understanding was expanded when she assisted other students because she could not simply tell them her answers, instead she had to review and analyze their target designs.

Judy and Demarkus felt the project’s checklist helped them to be responsible and self-regulate. Both mentioned the project engaged them more than teacher directed instruction because they were able to talk to their peers, use tools, and manually (hands on) do mathematics in a way other than with traditional tools like pencil and paper; however, Demarkus believed that projects led to excessive disengagement and extraneous talking for students who did not self-regulate.

Judy,

I like that the project gives a checklist of what needs to be done in a certain amount of time or a certain day. I like that the project gives hands on to students and allows students to think and respond to some questions after we have done the full project...having hands on and thinking at the same time, I think that entertains the students to try better at it...Hands on by using tools to find measurements, or we used them tools to draw the circles...Also, we used calculators. That's hands on, too… That kind of hands on stuff encourages students to learn more.

Demarkus,
I liked that we was with somebody. We wasn’t by ourselves, so it wasn't our responsibility on us. So, it made it even easier because it was broken into steps...We kids, we like doing stuff. We don't just like to sit down and look at something. We got to make us something. We got to have something to make us want to do it.... And we got to be, like, into it. We can't just be zoned out. If a teacher just standing there on her board just saying stuff, we all going to sleep and stuff, like, and just looking around and stuff; but, if we break it down like she did, like, in groups and assigned your responsibility… We get to talk, but some people take talking to a different level, like, they talk and don't get their work done.

Miyaa also commented on the ability to use tools to do mathematics and the increased engagement she noticed in her classmates.

Miyaa,

The complication of it. I like the drawing, I like circles, …

Yeah, because I see a lot of energy now since we have been doing projects. I see a lot of energy people put in their work. I think they have fun doing projects…Because you find your mistakes in projects, and you can fix them. You will have to start over, but you can always go back and you can fix them. You have to find out what you did wrong, and then you understand “Oh well, I cannot do it like this because it goes like that,” and then you will just understand it better.

Curt,

The project was easy, there was nothing that I disliked.

Curt explained that the hands-on nature of the project might increase student interest in mathematics. Curt, Judy, Demarkus, and Miyaa saw working on the project as an activity that
was engaging due to the novelty of using the compass and protractor as measurement tools to create a design and because they worked cooperatively with their peers to solve problems. Some participants added that the guidance provided by the checklist satisfied their need for structure and predictability; they knew what they needed to do each day and monitored their own progress towards completion.

Ann Marie, when asked if there was anything she did not like about the project group, said “No, not really. It was easy ... To me it was easy. I didn't really have a problem with it.” She thought the smaller size of the group enabled her to receive more assistance than when projects were worked on by the full class, “…I think that was good because people got more face-to-face contact instead of a bunch of people being in there, and she [teacher] can't get to everybody. Everybody got what they wanted.” Of all the participants, Ann Marie was the only participant to persistently have a negative attitude towards mathematics in her pre-data, but her attitude ostensibly shifted during the study.

**Station Rotation Instructional Strategy**

Ann Marie and the other ten participants expressed favor for the blended learning Station Rotations introduced during the study. The participants universally reported positive feelings towards the instructional model and suggested that Ms. Sunflower continue using the blended learning Station Rotations after the study ended. Some participants’ general attitudes about mathematics instruction changed after experiencing the model.

Ann Marie’s responses went from being consistently negative about mathematics and mathematics instruction in her pre-interview and survey to being lukewarm in the post-data. In her pre-interview Ann Marie said mathematics was her least favorite subject because, “…It’s hard… When she [teacher] explains it, I don’t understand it coming from her.” She said she
rarely felt competent to do mathematics, and her teacher was not able to explain mathematics so she could gain understanding. Before the study, she wanted the teacher to work with her individually rather than instructing a group of students. Ann Marie felt the teacher should, “Try to talk to us one-on-one. It’s a bunch of people in the classroom, and she don’t always get to everybody. Sometime, she can, like, if you ask her a question…She just everywhere!” She thought the teacher attempted to reach and assist each student during whole group instruction but was overwhelmed and was physically unable to assist each student when assistance was needed. Ann Marie was frustrated by the teacher’s inability to provide her with one-on-one assistance before the study.

Alternatively, when Ann Marie was asked in her post-interview if she liked math, she replied, “Kind of.” She explained that mathematics fluctuated in difficulty, but she knew she could do it if she worked hard. She said she was not good at doing mathematics but “…I work hard at it, so I keep a good grade in there though I don’t like it.” She felt her commitment and consistent tenacity enabled her to do mathematics. Her perception of her ability of competence in mathematics changed. Working in smaller groups was the most appealing part of the study for Ann Marie, “It's more brains. Yeah, you're not just by yourself. It's more knowledge coming,” and “I like that we got to work with a partner” she said. Her responses focused on her ability to learn from her peers during the study rather than her emphasis on learning directly from the teacher in her pre-interview. She continued to prefer instructions from a teacher to working on KA but felt the teacher’s instruction was not sufficiently explicit for her to understand, “I feel like she need to teach more. She teach, but at the same time, she don't teach enough for me to understand.” Like Vanessa, Ann Marie believed the teacher’s role was to “tell” her how to do mathematics. I inferred that Ann Marie disliked mathematics less after the study because she
received more one-on-one attention from the teacher although, in her opinion, the teacher did not adequately provide the procedural instructions she felt she needed to do mathematics. Ann Marie also gained an appreciation of the learning she acquired from interacting with her classmates and realized she could learn without direct assistance from the teacher. Of the participant group, Ann Marie reported the least favorable post-perceptions. The open-ended nature of the project and the KA exercises did not satisfy her desire for explicit instructions and procedures for doing mathematics.

The remaining participants were fond of being taught with a different instructional style each day. Some used the word “fun” to describe the variation of instruction. Rotating from working with the teacher to working on KA to working on a project each day was enjoyable, and as with Ann Marie, some expressed shifts in their attitudes towards mathematics instruction and their beliefs in their abilities to do mathematics. When asked about the blended learning and Station Rotations they experienced, the participants made various generally positive remarks. Demarkus,

… I'm starting to like it [math] because we are breaking it down more. It's not just, work, work, work, work. We get to do different stuff now; and, like, going to stations and, I like when we don't stay in a classroom the whole time. Like, if we're going with somebody else and then, with the stations. And, in our project I like that because we don't got to do it by ourselves and we get to do it with our partner, and we get help…so we can get it...Like, we're making it easier, basically.

…It’s not just silent, everybody do their work. We could do that sometime as part of the class, but we ain't got to do it every day. Sometimes we can break down into stations and
stuff like that and groups, like, how y'all been doing. And, splitting the classroom up and stuff.

Adrianna,

… I like it better that way...Because it's not like you got to do half of the work [by working in rotating small groups]. You've got to spend half of your time on Khan Academy. It's like you're switching it up so it's making it easier so you won't be doing just one thing… It does make learning easier because you're learning different things as you rotate. Ms. [Sunflower] she helps you, like she does the notes and we go with you to do the project and it helps… Because you're learning it different ways and in smaller groups… Say we were in a small group and people told you stuff helped you out that you might not have needed help in. You can help other people and then you have the teacher telling you different ways than your other teachers are telling you.

…When you're trying to teach the whole class, the whole class is not going to be quiet. If there were small groups and people working here, working there, it would be easier for her to teach that one group. The next day they could be rotated and then she could teach the next group. The other groups would do other things.

… I learned something that they [classmates] didn't know. Well, I learned something that I didn't know and they told me and I told them some stuff that I learned that they didn't know…. 

Adrianna emphasized the importance of the symbiotic learning that occurred when she discussed mathematics with her classmates in all three stations, and she believed the smaller groups increased student engagement. She said she was now good at math “Because when she [the teacher] gives us problems and stuff it's quicker for me to do them because I already learned it.”
She believed she was more capable of doing mathematics because of the rotations she experienced. When she was asked if she spent more time teaching or learning from her classmates, she replied, “More learning… Because when I need help they’ll be right there to help me. You only have one teacher so you've got to use your resources, your classmates, to help you.” Adrianna believed that she gained more understanding in her interactions with her classmates than she gave to her classmates. This feeling of unequal sharing of knowledge was repeated by Maya in her post-interview. Maya said she only received help from her classmates but never helped anyone. She also spoke positively of blended learning.

Maya,

…I liked how you did that, like you said, split up and able to focus on one thing instead of being all in one classroom doing it together, I guess…… Because they feel more comfortable to say their opinion [in small groups], I guess…I like it more now, the way we did it.

Maya reported that the blended learning she experienced caused her to like mathematics more. She felt that the smaller groups empowered her and her classmates to participate more actively in the learning process by giving them a safe environment to ask questions, engage in discussions, and get assistance. But she did not feel like she was any better at doing mathematics. When asked if she was better at math after the rotations she said, “Kind of the same…Because I get good grades sometime, but most of the time…I don’t really get the concept and end up not really doing good on tests…” She did not feel like her competence to do mathematics was impacted. This feeling of incompetence may have explained why she believed she received help from her peers but did not give help to others. Alternatively, Judy reported increased confidence in doing mathematics.
…I think I've improved in learning math. Like I said, being around lessor [fewer] people helped me learn more...I get more done on Khan Academy. I never got more than one check in one day, and I feel like working in a smaller group helps me focus on my work, so I'll be done with the assignment in like one day.

Curt said his ability to do mathematics successfully was unaffected by the study, but he liked the study because, “We get to do different things every day.” Learning mathematics using different rotating instructional strategies and sometimes in a different classroom with a different teacher was appealing to Curt and other participants. The blended learning model enabled them to do mathematics in a varying learning environment.

Summary

The findings of this study show that the ninth-grade geometry student participants had generally positive opinions of blended learning with the use of KA and PBL and were inspired to do mathematics by the Station Rotation instructional model. Their opinions on how each component of the model impacted their motivations and attitudes varied from student to student.

Differing reasons were cited for their positive opinions. The rotating instructional strategies and changing learning environment created freshness and excitement for some. All the participants reported that they liked working with the teacher in the teacher’s station where it was believed that they received more personal attention and interactions and higher quality instruction and could more frequently talk to their peers in comparison to whole group instruction. Some participants reported being motivated to do more mathematics on KA because they could work at their own pace and have choices in what topics to work on from the playlist. The participants interpreted KA’s points and badges as achievements, and they liked being permitted to get assistance from their classmates while working on KA. Collaboration with their
classmates while working on the project was again motivating, and the participants were moved to do mathematics by using measurement tools, using a checklist to guide their work, and by having a project that required individual as well as group accountability. The participants perceived talking about mathematics with their classmates as an essential part of learning when working with the teacher in her station, when working on KA, and when working on their target projects. Their emphasis on the importance of student-to-student discourse was reiterated throughout their interviews and surveys and was the most prominent finding of the study.

The participants disagreed on the impact of learning without direct assistance from the teacher. Ann Marie and Vanessa spoke positively of the study in general, but both desired more personalized attention and explicit instruction from the teacher. They resisted the lack of direct instruction during the study and believed the teacher’s role was to disseminate information and explain procedures for doing mathematics. Most of the other participants appreciated the autonomy of learning from their peers and from using KA to practice skills taught by the teacher. The participants differed on their perceptions of KA’s built-in incentive system. Curt, Steph, and Ann Marie were unaffected by the system; whereas, the other participants were moved by the energy points, badges, and/or avatars they accumulated. Most saw the energy points and badges as a source of pride and saw them as proof of their knowledge gains and ability to do mathematics. Some voluntarily discussed their energy points and badges with their family members and peers while some participants internally celebrated their energy points and badges. The system helped some of the participants to believe they were capable of doing mathematics with determination and effort.

In the fifth and final chapter of this dissertation, I will discuss the connections between the four research questions and the findings reported in this chapter.
Chapter 5: Discussion

“I would not use the word "like" because I still hear kids say, “I don’t like math.” It’s more they respect it because now, they are engaged. They’re doing it. They’re not complaining...Now they're thinking. I can see they’re thinking mathematically. I wouldn't use “like.” …I don't think the ones who came in hating math like it. Now they might hate it a little bit less, but now I see them [thinking] “I can do this. I'm not as bad as I thought I was.” Now I see them actually trying, whereas before, they just shut[down] whatever I gave them and put their head down.”

Ms. Sunflower, when asked after the study concluded if blended learning changed how much her students liked mathematics.

Within this chapter, I review and synthesize the major findings presented in chapter four. The analysis is connected to the study’s research questions. Unexpected findings are discussed. Implications and suggestions for using blended learning with Khan Academy (KA) and Project Based Learning (PBL) as a strategy for teaching mathematics are also discussed. The research questions are:

1. How is student intrinsic motivation to do mathematics impacted by blended learning with KA and PBL?
2. What are student perceptions and attitudes towards instruction that is blended with KA and PBL?
3. How are student feelings of competence, relatedness, and autonomy impacted by blended learning with the use of KA and PBL?
4. What particular features of KA impact student motivation to do mathematics?

This dissertation study was the result of my decades long search for teaching ideas and tools that motivated students to do mathematics. I wanted to inspire students to like and persist at learning mathematics, choose to take higher-level optional mathematics classes in high school and college, and pursue careers related to mathematics. Therefore, I investigated the possible
influences of Station Rotation blended learning with KA and PBL on student attitudes and motivations towards mathematics.

I examined the perceptions of 11 ninth grade students from one geometry class in an urban high-poverty largely African American high school. Comments from interviews with the teacher, Ms. Sunflower, were added to add clarity to the conclusions. The blended learning model was implemented over two weeks of instruction. The students were divided heterogeneously into three groups. One group worked with the teacher to learn new concepts, another worked on KA with laptop computers, and the third worked with me on a project where they were expected to design a dart board target. The student groups rotated daily from one station to another. The student participants completed pre- and post-written surveys and interviews. The teacher completed pre- and post-interviews.

The results were constrained by the lack of diversity among the participant group and my involvement as both a researcher and co-teacher in the study. The findings are intended to extend the limited body of existing knowledge on blended learning (Cavanaugh et al., 2009; Enyedy, 2014; Murphy et al., 2014b; O'Dwyer et al., 2007; Yarbro et al., 2014), the more limited existing body of knowledge of blended learning in K-12 settings (Means et al., 2010), and the limited extant research on KA (Murphy et al., 2014a). Due to the nature of qualitative study, the findings are not generalizable to all settings and are intended to provide “rich description” of the phenomenon (Merriam, 2009, p. 16).

The participants completed written surveys and interviews before and after the Station Rotation blended learning strategy was used. Observations of the participants’ behaviors and utterances before and during implementation of the study were recorded. A script was used to guide the interviews, but the questions evolved as more was learned about the participants. First
person participant quotes were the predominant form of data. The participants’ exact wordings were used to amplify and clarify their perspectives (Yin, 2014). The data were continuously analyzed after collection and were coded for final analysis. Multiple themes emerged from the analysis of the data. The themes were: (a) discourse; (b) personal attention; (c) KA’s built-in incentive system; and (d) choice.

**Major Findings**

Overall, the participants’ attitudes towards mathematics instruction were positively affected by the study. The participants were inspired to do and continue doing mathematics by Station Rotation, blended learning with KA, and PBL. All 11 participants reported positive dispositions towards the instructional model. They communicated a desire for the model to continue being used for mathematics instruction. The major findings are divided by the three stations of the model.

**Station Rotation.** The teacher’s station received positive comments from all the participants. The participants were inspired to persist at doing mathematics by the personal attention they received from the teacher in the group of about one-third of the class. They felt they had more opportunities to ask questions and engage interpersonally with the teacher and their classmates. It was also believed that students who normally did not engage in whole group discussions about mathematics did participate in discussions in the teacher’s station because they felt more at ease when fewer students were present. Being permitted to talk to their classmates during instruction was highly valued and was seen as a means of increasing mathematics understanding. The instruction in the teacher’s station was also perceived to be higher in quality and more time efficient than whole group instruction despite the similarity of the lessons the teacher delivered before and during the study. The participants felt the teacher permitted more
time for student-to-student discourse about mathematics in the station with fewer students because the smaller group was more manageable. Although less time was spent during the study working directly with the teacher Ms. Sunflower (every third class period), the participants felt the time they did spend with her was more effective than the whole group time they spent with her before the study.

**Khan Academy station.** Three participants, Curt, Ann Marie, and Steph, consistently did not care about KA’s built-in incentive system, but the remaining eight participants reported being motivated to continue doing mathematics by KA’s energy points, badges, and/or avatars by the end of the study. The energy points and badges were seen as visible accomplishments and were interpreted as signs of improving mathematical abilities. The participants infrequently discussed their KA accolades during class time. Choosing topics from the playlist, self-pacing, and getting help when needed from classmates rather than waiting for a teacher inspired the participants to persist at doing mathematics. The KA requirement to get consecutive answers correct was initially frustrating, but some became accustomed to the feature. The immediate feedback moved some participants to continue working on KA.

Vanessa and Ann Marie consistently preferred explicit teacher led instruction and feedback to KA. They were deterred by the perceived dissimilarities between KA’s and Ms. Sunflower’s strategies for doing mathematics. Due to home computer and Internet access issues, KA usage was limited to class time for all but Maya, Rey Ren, and Vanessa. About 95% of the participants’ KA time was spent completing the exercises; little time was spent playing KA’s instructional videos. Assistance from a peer or a teacher was preferred over playing a video. Further, the participants may not have watched the instructional videos (about three to five minutes in length) because they were concerned about completing their playlists during class
time since all but about three did not have computers and the Internet at home. A fraction of the KA videos could not be viewed using the school’s Internet because the videos were linked to YouTube, and the YouTube website was blocked on the school district’s server.

**Project station.** In the project station, participants reported being motivated by using mathematical tools, the novelty of the learning environment, being permitted to talk to their peers, and by their perceptions of individual accountability and autonomy. Although most appeared to be unfamiliar with the compass and protractor, using the tools to construct circles and measure angles was reportedly exciting. Some participants appreciated submitting individual projects (rather than submitting one project per group of students). These participants, Steph and Vanessa, believed they were not able to control their assignment grades when teachers required a group of students to work on and submit a single assignment for a group grade. However, the participants wholly wanted to work with at least one peer to ask questions, share ideas for solving problems, and discuss solutions.

**Role of discourse.** The impacts of student-to-student discourse, teacher-to-student discourse, and other personal interactions frequently surfaced in the data throughout the study. The participants saw engaging in the verbal exchange of mathematical ideas with both the teacher and their classmates as an imperative part of learning. This finding reverberated throughout the pre- and post-data. Demarkus and Adrianna expressed a belief that prohibiting student-to-student discourse (that they reported experiencing from previous mathematics teachers) was nonsensical and absurd; they did not understand why such a valuable resource, student-to-student discourse, was disallowed. The high value that was placed on discourse was evidenced by the repeated references to the understandings gained from verbal interactions.
during class time. The participants’ emphasis on discourse and receiving personal attention from their peers and the teacher were the most pervasive findings of the study.

**Connections to Previous Research and Literature**

The participants’ emphasis on student-to-student discourse in all three of the blended learning stations is supported by research from the National Council of Teachers of Mathematics’ (NCTM). Authors of NCTM’s (2000) *Principles and Standards for School Mathematics* and *Principles to Actions* (2014) stated that effective mathematics instruction includes student-to-student collaboration and discussion where students justify their thinking, make mathematical arguments, and critique the thinking of others. Student-to-student discourse clarifies mathematical understanding as students explain their reasoning (National Council of Teachers of Mathematics). The study participants seemed to intuitively realize that their informal arguments with other students when discussing mathematics improved their reasoning, mathematical thinking, and understanding.

Vygotsky’s Zone of Proximal Development (ZPD) learning theory asserted that social interactions with others resulted in higher understanding (Vygotsky, 1980). ZPD was described as the range of what a student is capable of understanding after conversation with a more knowledgeable person (Vygotsky). The student participants (and researchers) in previous studies on the use of KA also noted an increased amount of beneficial student-to-student discourse (Light & Pierson, 2014; Murphy et al., 2014a; Murphy et al., 2014b; Wiginton, 2013). In Light and Pierson’s (2014) study, the authors concluded that “KA transformed the typical peer-to-peer interaction from the exchange of correct answers to one of facilitation and guidance” (p. 111). Their participants reported having greater depth and substance in their interactions with their classmates when blended learning was used as an instructional strategy (Light & Pierson).
Additionally, Ryan and Deci (2000) posited that the social constructs within a classroom environment where students felt a sense of “belongingness and connectedness” (relatedness) promoted intrinsic motivation and persistence behaviors. Some participants, Adrianna and Demarkus, reverberated Ryan and Deci’s claim when they spoke of the common language that was shared by students and how discourse with their peers was more comprehensible and beneficial than discourse with adults. Participants also spoke of the increased opportunities for discussion with the teachers and their peers and getting their questions answered in the rotating groups; they may have felt a greater sense of community. Of the three stations, the teacher’s station and the project station were viewed positively by all 11 participants. Although students were permitted to talk and receive guidance from their peers when working on KA, I surmised that the teacher station and project stations were favored because all the students in those groups engaged in discourse and collaboration surrounding the same problems or exercises; whereas, on KA, the participants worked on individually selected topics and exercises. Students were permitted to talk to each other when working on KA but did not do so continuously because each was working on a different exercise.

Vanessa and Ann Marie’s continuous preference for assistance from the teacher over peer-to-peer assistance paralleled Wiginton’s (2013), Wilson’s (2013), and Yushau’s (2006) studies where some students resented learning on their own from using computer-based technology or through collaboration with their peers. Vanessa and Ann Marie saw the teacher as being the deliverer of knowledge and procedures for doing mathematics. The difficulty level of the KA exercises and the format of the program were initial deterrents for some participants, but over time, the participants became accustomed to the program’s requirements. Only Ann Marie
consistently expressed disdain for KA. She preferred receiving one-on-one explicit assistance and from the teacher to working on KA.

This study’s finding that the participants were motivated by KA was consistent with the larger study *Research on the Use of Khan Academy in Schools* where almost three-quarters of the participants said they enjoyed using KA and 32% said they liked mathematics more as a result of using KA (Murphy et al., 2014a). Fifty-six percent of the grade 5-8 and 28% of the high school participants in *Research on the Use of Khan Academy in Schools* said the points and badges were motivating (Murphy et al., 2014a). The surveyed participants (n ≈ 800) were in a low poverty school district; they may have had higher pre-existing attitudes towards mathematics instruction than the participants in my study because my participants were in a high poverty school. Socioeconomic status is known to have a direct correlation on student attitudes towards school (Palardy, 2013).

Some additional authors of studies reported that students perceived KA to be “fun” (Light & Pierson, 2014) and noted increased student engagement (Bernatek et al., 2012; Murphy et al., 2014b). Participants in an Australasian study on KA, reported a fondness for controlling their own learning by watching or re-watching a video and choosing which exercises to complete from a playlist (Muir, 2014). Thirty-five percent of the teachers in the high poverty sites studied in the study *Research on the Use of Khan Academy in Schools* felt that KA had a strong impact on the students’ motivation to learn mathematics, and 80% of the teachers believed that immediate feedback received on KA helped students to be self-aware of their progress and helped students to make supportive decisions like seeking assistance or working on a particular exercise set (Murphy et al., 2014a). The three Summit charter school teachers who participated in the *Blended Learning Report* study also shined a positive light on KA (Murphy et al., 2014b). All
three teachers recommended the use of KA; they believed KA enabled students to regulate their own learning, provided self-paced instruction, and reported that using KA increased student engagement (Murphy et al.). Additionally, like my study, the Summit teachers used KA as a station in the Station Rotation instructional model.

The participants’ universally positive perceptions of the project station were also consistent with previous research on PBL. Extant research posits that usage of PBL in K-12 STEM classes increases student interest, attitudes, and engagement (Catapano & Gray, 2015; Fantz & Grant, 2013; Kanter & Konstantopoulos, 2010; Lou et al., 2011; Thomas, 2000; Tseng et al., 2013).

Challenges

Conducting research with students in a school with an inflexible set schedule, calendar of events, and curriculum was challenging. The study was unavoidably interrupted by a two-week gap of instruction because there were not two continuous weeks of instruction on the school’s calendar before state testing began in April of 2016. State testing disrupted the school’s daily class period schedule. There were other logistical issues that had to be resolved to implement the study. For example, the participants were in Ms. Sunflower’s third class period. Ms. Sunflower wanted to use the same instructional model for all her classes because she thought it might be too difficult, as a new teacher, to use Station Rotation in one class and not in the others. I was able to train the intervention specialist (special education teacher) Ms. Jones in supporting Ms. Sunflower with the instructional model, but Ms. Jones was only available to support three class periods. Ms. Sunflower needed support for her sixth period class so that she could use the lesson we had planned for all her geometry classes. No additional building staff members were available, so the study had to be scheduled for dates that I could co-teach in both third and sixth
bells. I co-taught Station Rotation blended learning with KA and PBL in two of Ms. Sunflower’s classes but only collected data from one class. We made the decision for me to co-teach in the sixth bell class a few weeks before the study began. There was not adequate time to amend documents for City University’s institutional review board or for the school district’s research review board to include data from the sixth period class in this study.

I had hoped to begin the study in the fall of 2015 after the study was approved by City University, but the study was delayed until the spring of 2016 because it was not yet approved by the school district’s research review board. The school district’s review process was similar but not identical to City University’s institutional review board’s process. The school district forbade videotaping and required some wording changes to various documents in the application causing further delay. The school district’s research application could not be submitted until City University’s approval was received, and the school district’s approval was only valid for the current school year. Because the two processes could not occur concurrently, the start date was delayed and was limited to the remaining school days in the school year 2015-16. It was challenging to find a teacher to host the study, get approval from the principal, obtain the university’s approval, achieve approval from the school district, assent and consent the participants and their parents/guardians, and plan and conduct the study within one school year. Additionally, because video recording was prohibited, I was unable to audio record the discourse that was found to be impactful. Quoting student-to-student and student-to-teacher vocal interactions would have enabled me to assess the content for possible changes in the participants’ expressions of their mathematical thinking.

This study was also challenged by the constantly changing format of the web-based KA program. The students occasionally encountered videos on KA that were linked to YouTube
KA’s original video storage site) and were blocked by the school district, but the more recent videos were stored with another site and were accessible from school. The playlists that were used in this study originated from coach resources that were posted prominently in KA “coach resource” module which was linked on KA’s homepage. The example playlists are no longer featured on the website. Instead, teachers are encouraged to assign specific exercises to individual students. This feature was available during the implementation of the study but was in beta format. Ms. Sunflower and I attempted to use the feature with mixed results. Some students were able to view the assignments, and some were not; therefore, we did not use the feature during the study. Being able to assign work to specific students or student groups would have enabled us to individualize the students’ experiences on KA to create mastery learning. Mastery learning is when students have their own learning paths at their own achievement levels; students are introduced to new topics only after prerequisite topics are mastered (Bloom, 1984; Khan, 2012). Mastery learning is posited to positively impact learner engagement, attitudes towards mathematics (Bloom, 1984), and achievement (Bloom, 1984; Wambugu & Changeiywo, 2008).

Wiginton’s (2013) mixed-methods dissertation study examined the student self-efficacy in two Algebra I flipped blended learning classes over sixteen-weeks where KA and an online textbook were used for instructional assistance. According to Bandura and Adams (1977), self-efficacy, the belief that one can successfully accomplish a task, is the foundation of human motivation. In one class in Wiginton’s study the students were assigned the same topics (as was done for my study) and in the other class a mastery approach was used where students were assigned topics as they individually mastered a previous prerequisite topic. The results from the mastery learning class showed the most promise. Both classes of students reported being
“satisfied” with the instructional models, but the students in the mastery learning class indicated increased self-efficacy with a small effect size of .128 on pre- and post- surveys (2013). Wiginton stated,

…As they [students] successfully mastered their tasks, they began to believe that it was possible to understand mathematics at a higher level. Each subsequent success raised students’ mathematics self-efficacy. This was observed in the classroom, as emotional displays of celebration would erupt whenever a unit was mastered (2013, p. 215).

Ms. Sunflower and I were unable to assign individual exercises within the two-week duration of my study. Had the duration of my study been longer and if KA’s now available feature had been used to assign individual exercise sets to each student to implement mastery learning, the results may have been different. One teacher in the Blended Learning Report study also felt that KA’s impact may have been different if students had been able to do KA at their appropriate achievement level rather than their grade level (Murphy et al., 2014b). The students in the Blended Learning Report study were all expected to complete the same grade level assignments; they were not given a playlist of assignments to complete. The three teachers in the study noted that engagement was the highest for their higher achieving students, and some struggling students seemed dispirited when they were not able to complete the weekly assignments (Murphy et al.). Student achievement and attitudes towards mathematics are positively correlated (Dumais, 2009; Ma & Kishor, 1997). As seen by Wiginton (2013), the participants in my study and in the Blended Learning Report may have been more efficacious had they received assignments at their current level of achievement.

I detected changes in KA program’s homepage and overall organizational format at the end of every summer since I began studying KA in 2011. The changing KA program may make
it difficult for researchers to replicate this study and might compromise the usefulness of research conducted on a version of KA that differs from a currently available version of the program.

**Unexpected Findings**

Media attention on KA has often focused on usage of the instructional videos as a teaching tool (Banerjee, 2015; Gupta, 2012; Meyer, 2014; Schwartz, 2014; TED2011, 2011; Thompson, 2011), but the largest study of KA, *Research on the Use of Khan Academy in Schools*, showed that teachers primarily used KA to practice previously taught topics, and students only used the instructional videos as a last resort for assistance (Murphy et al., 2014a). About 15% of the students’ time in *Research on the Use of Khan Academy in Schools* was used for playing videos (Murphy et al.), but only about five percent was used during my study. I did not expect that only 35 videos would be played in the duration of the study. Ann Marie, Curt, Miyaa, and Steph did not play any videos. I construed that some students did not play KA’s instructional videos because they had a limited amount of class time to complete their assignments, many did not have headphones to listen to the videos without audible distractions, and the assigned exercise sets were on topics that had already been introduced by the teacher.

Another unexpected finding was that the pre-written surveys and interviews revealed that the participants generally ascribed to Dweck’s (Blackwell et al., 2007; Dweck, 2006) growth mindset principles. Some participants believed that some students were born better at doing mathematics and learned mathematics faster than others (fixed mindset) (Blackwell et al.; Dweck), but they all expressed the belief that anyone could successfully do mathematics with effort, hard work, and tenacity. They perceived themselves as controlling their progress, locus of control, at doing mathematics (Schunk, Meece, & Pintrich, 2008). “Students who believe they
have control over whether they succeed or fail should be more motivated to engage in academic
tasks, expend effort, and persist on difficult material than students who believe their actions have
little effect on outcomes” (Schunk et al., 2008, p. 244). The assertion that having an internal
locus of control leads to persistence contradicted the student behaviors that Ms. Sunflower and I
observed before the study began. We observed some signs of learned helplessness (Diener &
Dweck, 1978) in the students’ behaviors. When asked to complete mathematical tasks, the
students sometimes depended on the teacher for constant assistance and direction instead of
discussing the problems with a peer, referring to their notes, or struggling through the tasks on
their own. They appeared to withdraw rather than to expend effort to complete tasks. This
observation could have been the result of the American tradition of students being accustomed to
being rescued and directed through learning mathematics by teachers (Hiebert & Stigler, 2004).
In the pre- and post- data, the participants professed to believe that anyone could be successful at
doing mathematics with effort, yet at the beginning of the study only some seemed to routinely
expend effort during mathematics class. I surmise that some students may have responded
affirmatively when asked if anyone could be good at doing mathematics because they had
experienced school-wide growth mindset promoting activities in their homeroom (advisory)
periods. They may have responded affirmatively because they thought Ms. Sunflower and I
were hoping they would respond affirmatively, but I remain unconvinced that some participants
actually believed that anyone could be good in mathematics with effort before the study began
given my observations of some of their resigned behaviors.

Finally, the impact of allowing the participants to make decisions in their own learning
process was unexpected. I underestimated the positive effect of choice on motivation. Although
choice is claimed to increase intrinsic motivation in Ryan and Deci’s Self-Determination Theory
(Deci & Ryan, 1985; Ryan & Deci, 2000; Ryan & Deci, 2009), I did not expect the participants to spontaneously mention the choices they were afforded (the exercise sets on the playlists, decisions on what level of mastery to work towards on the playlist, and the design of their target) as justification for their favor of the study. The impact of student choice was unexpected because as a seasoned educator I see few opportunities for student choice in mathematics classrooms.

**Conclusions**

I interviewed Ms. Sunflower before and after the study. She and I also debriefed during planning sessions and after school. Her perspectives on the impact of the instructional model, blended learning with KA and PBL, mirrored the student participants’ perspectives and gave some additional insights. When Ms. Sunflower was asked in her post-interview, “Do you think that it [KA] motivates the students to learn?” She replied,

Yes, you just have to point out the different aspects of it. For example, the badges, because a lot of kids get frustrated when they can’t move on, because they keep getting the same problem wrong over and over. However, when they hear the ding ding ding at the end, you can see the smile or they start to cheer …

To her, KA’s points and badges system moved students to continue doing mathematics. She believed some students were initially irritated by the difficulty of the KA exercises, but their confidence grew as they successfully completed exercises and received badges. As a result, they increasingly persisted at doing mathematics. When asked if she prodded the students to complete KA’s Mastery Challenges (optional assessments), Ms. Sunflower said,

I think it’s more from each other. I’ve never said anything like “Take the Mastery Challenge.” I give them the option to either move on to the next topic and
practice…[they] say, “Go,” and the kids tell each other how you find the Mastery Challenge. Then their classmates say, “Take it. Even if you get it wrong, it might bump you up in level one instead of mastery, and then that way you don't have to do as many.” … I see more prompting from students for other students to get that mastery than it is for me as a teacher.

She observed the students promoting perseverance amongst each other. In her opinion, the students created a learning community where they encouraged each other to accept challenges and take risks (by spending some of their class time completing the Mastery Challenge assessments). Regarding student-to-student discourse and choice she said,

I see arguments about the math…students raise their voice, which I also have to remind them, “We have to use quiet voices, even if it is math we're discussing.” They're more engaged. I’ve heard vocab used a lot more, and they like to bounce ideas off of each other… They get some choice, which I also think some of them struggled with at first.

She explained that the students were initially uncomfortable with the autonomy they were afforded. She said she encouraged the students’ self-assurance in their decision-making skills by,

Instead of saying, “No, that’s the wrong answer…” saying, “I like your thoughts,” or “Okay, I can see how you got that.” Even having each other explain their choices…and then ask for other students to agree or disagree and explain themselves.

Ms. Sunflower believed the students were accustomed to there being exactly one correct answer for solving a mathematics task and that there was always only one correct solution. She thought that before the study, some students sought immediate feedback from her because they lacked confidence; they wanted her to tell them if their mathematics work was right or wrong. Some
participants’ appreciation of the immediate feedback they desired from the teacher was reminiscent of the appreciation for immediate feedback on KA. She said she tried to create a classroom environment where students were encouraged to share their mathematical thinking. According to Ms. Sunflower, mathematics classrooms should be places where students discussed alternative strategies to foster the notion that mathematics problems and exercises could be solved with more than one strategy, and there were sometimes multiple solutions. She thought that her acceptance of multiple strategies and solutions increased the students’ confidence and persistence at doing mathematics and having approximately one-third of the class in her teacher’s station allowed her to verbally interact more with each student in comparison to whole group instruction. The station of fewer students enabled her to interact more meaningfully with her students. To her, these interactions both improved understanding and increased the students’ efficacious beliefs.

**Research questions.** “How is student intrinsic motivation to do mathematics impacted by blended learning with KA and PBL?” And, “What are student perceptions and attitudes towards instruction that is blended with KA and PBL?” Deci and Ryan’s (1985) Self-Determination Theory delineated differences in various types of motivation. The psychologists described *intrinsic* motivation as “doing something because it is inherently interesting or enjoyable” (Ryan & Deci, 2000, p. 55). Intrinsic motivation was sought after because it was thought to lead to “high-quality learning,” feelings of satisfaction, and persistence while extrinsic motivation was thought to lead to decreased attitudes towards the task (Ryan & Deci). All 11 participants expressed positive attitudes towards the Station Rotation, blended learning with KA, and PBL instructional model. Mathematics instruction was perceived as interesting and enjoyable due to the participants’ described increased opportunities for meaningful discourse,
personal attention, choice, use of tools, and novelty. Not all participants enjoyed every aspect of the model, but overall the model was favored over conventional whole group mathematics instruction which they had experience prior to the study.

“How are student feelings of competence, relatedness, and autonomy impacted by blended learning with the use of KA and PBL?” The instructional model satisfied the conditions of Ryan and Deci’s Self-Determination Theory (Deci & Ryan, 1985; Ryan & Deci, 2000; Ryan & Deci, 2009) where learners’ needs for feelings and competence, autonomy, and relatedness must be addressed to inspire motivation. Some participants expressed increased feelings of competence because of: (a) KA’s built-in incentive system of energy points, badges, and avatars; (b) the successful completion of KA’s exercise sets; (c) tracking their own progress on the KA playlist and project checklist; and, (d) from engaging in meaningful discourse with their teacher and peers. The back-and-forth assistance that occurred during student-to-student discourse and the personalized attention received in the teacher’s station led to a heightened sense of belongingness or community (relatedness) for some. Ms. Sunflower said, “It keeps them all engaged.” She estimated that nearly 100% of her students were engaged during the study,

I want to say a hundred percent...the majority are engaged. I don’t know if that’s just because they say, “Now she can see me and she can stand right next to me” type thing, or is it because now they feel like they are important and they matter.

She went on to describe how the model helped students to feel like they were part of a learning community where their individual needs were valued,

It gets them more of an individual learning process rather than getting pushed off to the side and saying, “You don't matter in class.” I think it gave them a sense of “I belong in here.” Whereas in the beginning of the year, a lot of them were just overlooked.
She believed the students’ needs were met through self-paced work and the choices (autonomy) given on KA and the project and using the teacher’s station to develop new mathematical concepts with a reduced sized group of about one-third of her class. The KA assignment playlist and the target project were perceived as opportunities for self-regulation and control. Student needs for feelings of competence, relatedness, and autonomy were addressed by some of the conditions of the study.

“What particular features of KA impact student motivation to do mathematics?” Eight of the 11 participants were compelled to persist at doing mathematics on KA by their accumulation of energy points, badges, and/or the leveling up of their personal avatar. The immediate feedback the participants received, self-paced learning, and the chance to make decisions on the KA playlist were inspiring. KA was seen as a flexible learning environment where the participants were given choices. Some participants appreciated receiving alternative explanations for doing mathematics on KA while other participants resented the perceived differences between KA and their teacher’s explanations. Some participants also viewed working on KA as a welcomed change from whole group instruction; having variation in their learning environment was inspiring.

**Future research and professional development.** The 2014 Speak Up (Project Tomorrow and The Flipped Learning Network, 2015) survey of more than 4,000 school administrators reported that the number of teacher-created instructional videos were on the rise. As mentioned, Vanessa and Ann Marie preferred explanations from the teacher to KA. Future studies might examine the impacts of teacher created videos versus KA tutorial videos or the tutorial videos of similar online programs. Scientific randomized controlled studies with rigid protocols for using KA should be conducted to elucidate the impacts of using KA and blended
learning expanding the limited body of existing knowledge on KA (Means et al., 2010) and blended learning in K-12 settings (Murphy et al., 2014a). Future studies might also examine the personal characteristics of students to explain why students are impacted differently by blended learning with KA and PBL.

Teachers and school administrators who decide to adopt blended learning may need training on the instructional model. Teachers may also need training on strategically using student grouping, KA, and PBL to facilitate rich student-to-student and teacher-to-student discourse. This study examined the Station Rotation blended learning model, but teachers may find other models such as Lab Rotation, Flex Model, Individual Rotation, Flipped Model, and various other models (Horn & Staker, 2014) to be more suitable. Training on blended learning should introduce a variety of instructional models to allow teachers and school administrators to adopt the most appropriate instructional model for their students’ needs, physical learning spaces, and available technology. Teachers may need professional development on using the data generated from KA as a formative assessment tool to inform and plan mathematics instruction.

**Implications.** In this study, students used KA as an online tutorial program for supporting blended learning in mathematics, but the findings may be helpful for educators seeking a greater understanding of blended learning with other tutorial programs. The strengths and weakness of the KA program, as they relate to learner motivation, are elucidated. This information might be helpful when selecting an online tutorial program to address student needs. The findings may also be informative for those considering using blended learning in other academic disciplines and might be particularly useful for those considering implementing Station Rotation blended learning and how the stations may affect learner attitudes.
References


Appendix A:

Principal Letter

Principal

I am in the final stage of my doctoral studies at the University of Cincinnati. My dissertation topic is "Does Blended Learning with Khan Academy and Project Based Learning Impact Student Motivation to do Mathematics?" I hope to complete the study with geometry teacher TEACHER. The study will take about three to four weeks. I plan to begin in January. I will work with TEACHER to implement station-rotation blended learning and collect data on the student and teacher perceptions of the instructional model. As you know, I am TEACHER’s Woodrow Wilson Fellowship program mentor. I already mentor her by coaching and visiting several classes each month.

TEACHER and I are already using blended learning in her classroom. My study will simply allow me to collect data on the instruction she is implementing. We currently have the students working in two groups on block bell days. Once the study begins, the students will be divided into 3 groups. TEACHER will deliver small group targeted instruction to one group, I will work with another group on project-based learning, and the third group will work on a Khan Academy playlist (list of expected assignments). The groups will rotate daily creating the station-rotation model of blended learning. The goal is to deliver personalized and engaging instruction.

All data will be collected from TEACHER’s 3rd bell class of about 32 students. The data will include student pre- and post- written surveys regarding their interest and motivation to do mathematics, pre- and post- interviews of 5-10 students, pre- and post- teacher interviews of TEACHER, and video recordings of students working throughout the study. The video recordings will be used to gauge student engagement. After the study concludes, I will continue to mentor TEACHER through the end of the school year.

I worked for SCHOOL DISTRICT for 10 years as a classroom teacher and 4 years as out-of-class Lead Teacher for the Peer Assistance and Evaluation Program. Before leaving the classroom at SCHOOL, I was evaluated as an Accomplished teacher on CPS' Teacher Evaluation System. I have an active school administration and teaching licenses. I wish to complete my study in an urban environment because I am committed to increasing interest in mathematics particularly for students who are members of underrepresented communities.

I am available to meet if you have additional questions. Do I have your approval to conduct my dissertation research at your school? Thank you for your consideration.

Sincerely,

Lori Cargile
Appendix B:

Teacher Consent

Title of Study: Does Blended Learning with Khan Academy and Project Based Learning Impact Student Motivation to do Mathematics?

Introduction:

You are being asked to take part in a research study. Please read this paper carefully and ask questions about anything that you do not understand.

Who is doing this research study?

The people in charge of this research study are Lori Cargile and Dr. Shelly Harkness of the Curriculum and Instruction Department of the University of Cincinnati’s School of Education.

What is the purpose of this research study?

The purpose of this research study is to:

Understand the impact of using the instructional model, blended learning, with Khan Academy (KA) and project based learning (PBL) on the student participants’ motivation to do mathematics, their attitudes towards mathematics, and attitudes and perceptions of KA and PBL.

Who will be in this research study?

About 30 of your students (one class) and you, their math teacher, will take part in this study. You are being asked to participate because you are a licensed secondary math teacher who already uses technology as part of your instruction.

What if you are an employee where the research study is done?

Taking part in this research study is not part of your job. Refusing to be in the study will not affect your job. You will not be offered any special work-related benefits if you take part in this study.

What will you be asked to do in this research study, and how long will it take?

You will be asked to be interviewed before and after the study. The study will take about two weeks.

- The interviews will take about 30 minutes to complete and will be audio recorded and then transcribed.
- The interviews will be conducted at school during the school day.
- The interviews will ask you to explain your perceptions of student motivation during traditional math instruction, computers assisted instruction, small group instruction, and
project based learning.

**Are there any risks to being in this research study?**

It is not expected that you will be exposed to any risk by being in this research study.

**Are there any benefits from being in this research study?**

You will probably not get any benefit because of being in this study. But, being in this study may help educators understand blended learning.

**What will you get because of being in this research study?**

You will not be paid (or given anything) to take part in this study.

**Do you have choices about taking part in this research study?**

If you do not want to take part in this research study you may simply not participate.

**How will your research information be kept confidential?**

Information about you will be kept private by the using a pseudonym on written documents and on the transcriptions of your interviews. Your name will not be on any written documents other than the consent form. Your pseudonym will be used in the interviews. Your school and school district will not be identified. Pseudonyms will be used for your school and school district.

Your written information will be kept locked in the researcher’s personal cabinet at the University of Cincinnati. Electronic information will be stored on the researcher’s password protected University of Cincinnati computer until data analysis is complete. After that it will be destroyed by shredding or deletion.

Agents of the University of Cincinnati may inspect study records for audit or quality assurance purposes.

**What are your legal rights in this research study?**

Nothing in this consent form waives any legal rights you may have. This consent form also does not release the investigator, the institution, or its agents from liability for negligence.

**What if you have questions about this research study?**

If you have any questions about this research study, you should contact Lori Cargile at PHONE NUMBER. Or, you may contact Dr. Shelly Harkness at PHONE NUMBER.

The UC Institutional Review Board reviews all research projects that involve human participants to be sure the rights and welfare of participants are protected.
If you have questions about your rights as a participant, complaints and/or suggestions about the study, you may contact the UC IRB at PHONE NUMBER. Or, you may call the UC Research Compliance Hotline at PHONE NUMBER, or write to the IRB, 300 University Hall, ML 0567, 51 Goodman Drive, Cincinnati, OH 45221-0567, or email the IRB office at irb@ucmail.uc.edu.

**Do you HAVE to take part in this research study?**

No one has to be in this research study. Refusing to take part will NOT cause any penalty or loss of benefits that you would otherwise have. During the interviews, you may skip any questions that you don't want to answer. You may start and then change your mind and stop at any time. To stop being in the study, you should tell contact Lori Cargile at PHONE NUMBER. Or, you may contact Dr. Shelly Harkness at PHONE NUMBER.

**Agreement:**

I have read this information and have received answers to any questions I asked. I give my consent to participate in this research study. I will receive a copy of this signed and dated consent form to keep.

Participant Name (please print) ________________________________

Participant Signature _____________________________ Date _______

Signature of Person Obtaining Consent _____________________________ Date _______
Hello parents of X High School students,

My name is Lori Cargile. I am in the last year of doctoral studies at the University of Cincinnati. As part of my program, I am completing a research study on how using computers, small group learning, and projects to help teach math affects student interest and motivation to do math.

Your child’s math teacher is allowing me to study one of her classes. Your child is in the selected class. The participating students will be surveyed in math class before and after the study. About 5 -10 students will also be interviewed before and after the study. The interviews will be audio recorded, and the recordings will be deleted once typed (transcribed). I will also view your child’s Khan Academy usage data. The purpose of the surveys, interviews, and usage data is to understand your child’s feelings and attitudes about math and math class. During the study, all students will work on computers (Khan Academy), do a hands on project, and work in a small group with the teacher. I will also be present to assist the students during the study. The study will last about two weeks. Participation or non-participation in the study will not affect your child’s math grades. Your child will be expected to complete regular school work as given by the teacher regardless of participation in the study.

All of your child’s information will be secured and kept confidential. Your child will select a fake name (pseudonym) to use on the written surveys and in the interviews.

The goal of this research is to help educators to understand ways to change student motivation and interest in math. I am a state licensed math teacher and administrator. I have 18 years of experience as a former classroom teacher and school administrator. Please do not hesitate to contact me if you have any questions or concerns.

Sincerely,

Lori Cargile, Doctoral Candidate

PHONE NUMBER
Appendix D:  

Parent Permission

Title of Study:

Does Blended Learning with Khan Academy and Project Based Learning Impact Student Motivation to do Mathematics?

Introduction:

You are being asked to allow your child to take part in a research study. Please read this paper carefully and ask questions about anything that you do not understand.

Who is doing this research study?

The person in charge of this research study is Lori Cargile of the University of Cincinnati (UC) Curriculum and Instruction Department of the School of Education. She is being guided in this research by Dr. Shelly Harkness.

What is the purpose of this research study?

The purpose of this research study is to:

Understand the effects of using computers (Khan Academy), math projects, and teaching in small groups on student motivation to do math.

Who will be in this research study?

About 30 children and their math teacher will take part in this study. Your child may be in this study if he or she is in the participating teacher’s math class at Hughes High School.

What will your child be asked to do in this research study, and how long will it take?

The duration of the study is about two weeks. All students will rotate each bell/class period in three groups: small group instruction, projects, and Khan Academy as part of their regular class activities. The type of instruction your child receives will not be affected by participation in the study.

Your child will be asked to complete a written survey before and after the study. The survey will take about 20 minutes to complete. About 5-10 of the students will be asked to participate in interviews before and after the study. The student interviews will be audio recorded and typed. The interviews will take about 30 minutes to conduct and will take place at a convenient time during the school day. Your child’s Khan Academy usage data will be recorded.

Are there any risks to being in this research study?
It is not expected that your child will be exposed to any risk by being in this research study.

**Are there any benefits from being in this research study?**

Your child may benefit from the opportunity to express his or her feelings about math class. The study may also help educators who want to know more about how children feel about math and learning with the use of computers, small learning groups, and projects.

**What will your child get because of being in this research study?**

Your child will not be paid (or given anything) to take part in this study.

**Does your child have choices about taking part in this research study?**

If you do not want your child to take part in this research study he or she may simply not participate in the surveys and interviews. Audio taping is required for participation in the interviews. Your child will not be treated any differently if he or she does not participate.

**How will your child’s research information be kept confidential?**

Information about your child will be kept private by using fake names (pseudonyms) on written documents. Only the researcher will know your child’s fake name. The teacher will not know your child’s fake name and whether or not your child is participating in the study. The audio recordings will be erased once they are typed (transcribed). The audio recordings will only include your child’s fake name. Your child’s assent and consent forms and surveys will be kept in a locked cabinet on the University of Cincinnati’s campus until the data is analyzed. Electronic information will be kept on a password protected University of Cincinnati computer. After analysis is complete, all student information will be shredded or destroyed by deletion.

The data from this research study may be published; but your child and your child’s school will not be identified by name.

Agents of the University of Cincinnati may inspect study records for audit or quality assurance purposes.

**What are your and your child’s legal rights in this research study?**

Nothing in this consent form waives any legal rights you or your child may have. This consent form also does not release the investigator, the institution, or its agents from liability for negligence.

**What if you or your child has questions about this research study?**

If you or your child has any questions or concerns about this research study, you should contact
Lori Cargile at PHONE NUMBER. Or, you may contact Dr. Shelly Harkness at PHONE NUMBER.

The UC Institutional Review Board reviews all research projects that involve human participants to be sure the rights and welfare of participants are protected.

If you have questions about your child's rights as a participant, complaints and/or suggestions about the study, you may contact the UC IRB at PHONE NUMBER. Or, you may call the UC Research Compliance Hotline at PHONE NUMBER, or write to the IRB, 300 University Hall, ML 0567, 51 Goodman Drive, Cincinnati, OH 45221-0567, or email the IRB office at irb@ucmail.uc.edu.

Does your child HAVE to take part in this research study?

No one has to be in this research study. Refusing to take part will NOT cause any penalty or loss of benefits that you or your child would otherwise have. Your child may skip any survey or interview questions that he or she doesn't want to answer.

You may give your permission and then change your mind and take your child out of this study at any time. To take your child out of the study, you should tell the math teacher.

Your child will be asked if he or she wants to take part in this research study. Even if you say yes, your child may still say no.

Agreement:

I have read this information and have received answers to any questions I asked. I give my permission for my child to participate in this research study. I will receive a copy of this signed and dated Parent Permission form to keep.

You Child's Name (please print) ____________________________________________

Your Child's Date of Birth _______________ (Month / Day / Year)

Parent/Legal Guardian's Signature ___________________________ Date ________
Appendix E:

Youth Assent

Title of Study: Does Blended Learning with Khan Academy and Project Based Learning Impact Student Motivation to do Mathematics?

Introduction: You are being asked to be in a research study. Please ask questions about anything you do not understand.

Who is doing this research study?

The people in charge of this research study are Lori Cargile and Dr. Shelly Harkness of the University of Cincinnati (UC) Curriculum and Instruction Department of the School of Education.

What is the purpose of this research study?

Understand how using Khan Academy, small groups, and projects affect your feelings about doing math in math class.

Who will be in this research study?

Your class of about 30 students and your math teacher will take part in this study.

What will you be asked to do in this research study, and how long will it take?

You will be asked complete a survey in class before the study starts and after the study is finished. Some students will be interviewed before and after the study. In class you will do a project, work in small groups, and use online tutorial program Khan Academy to practice math. The study will take about two weeks. The research interviews and survey will take place at school.

- About 5-10 students will be interviewed.
- The surveys will take about 20 minutes to complete.
- The interviews will take about 30 minutes to complete and will be audio recorded.
- The interviews and survey will be conducted at school during the school day.
- The surveys and interviews will ask you to explain how you feel about math class, computers, small groups, and projects.
- Your Khan Academy usage data will be recorded.

Are there any risks to being in this research study?

It is not expected that you will be exposed to any risk by being in this research study.
Are there any benefits from being in this research study?
You may benefit from the opportunity to express your feelings about math and math class.

What will you get because of being in this research study?
You will not be paid (or given anything) to take part in this study.

Do you have choices about taking part in this research study?
If you do not want to take part in this research study you may simply not participate in the surveys and interviews. You will not be treated any differently. There is a place at the end of this paper to mark your choice. Participation in this study does not change how you will be graded. You will complete assignments as required by your teacher. You will learn the normal math topics as required by your school district.

How will your research information be kept confidential?
Information about you will be kept private by using your fake name on written documents and on audio recordings. Your written information will be kept locked in a cabinet at UC, and your electronic information will be stored on a password protected UC computer. After data analysis is complete, your information will be shredded or deleted.

What are your legal rights in this research study?
Nothing in this assent form takes away your rights.

What if you have questions about this research study?
If you have any questions about this research study, you should contact Lori Cargile at PHONE NUMBER. Or, you may contact Dr. Shelly Harkness at PHONE NUMBER.

Do you HAVE to take part in this research study?
No one has to be in this research study. You will not get in any trouble if you say no. You may skip any questions that you don't want to answer. You may start and then change your mind and stop at any time. To stop being in the study, you should tell your math teacher.

Agreement: I have read this information. I want to be in this research study.

Your Name (please print) ____________________________________________

Your date of birth ________________ (Month / Day / Year)

Your Signature ___________________________ Date ___________

Signature of Person Obtaining Assent ___________________________ Date ___________
## Appendix F:

**Teacher’s Station Procedures**

<table>
<thead>
<tr>
<th>Teacher’s Station Procedures &amp; Teaching Notes</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class Periods 1-3</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Area of Pi and Area of Circles</strong></td>
<td>Student group and subgroup lists with 3 copies.</td>
</tr>
<tr>
<td>1. Springboard, Algebra I textbook: 32-1, p. 463, #1-5 After completing #1, the teacher should use a string to measure at least two additional circles with a string or a measuring tape to confirm the C/d ratio (pi). The demo circles can be drawn/traced on the board.</td>
<td></td>
</tr>
<tr>
<td>2. Slide 4 - TEACHER reviews the history of pi slide and emphasizes the role of the African Egyptians (Students often do not realize that the discoveries of ancient Egypt occurred in Africa.)</td>
<td></td>
</tr>
<tr>
<td>3. Springboard, Algebra I textbook: 32-1, p. 464 Use handout from “Discovering the Area Formula for Circles” from NCTM <a href="https://illuminations.nctm.org/Lesson.aspx?id=1852">https://illuminations.nctm.org/Lesson.aspx?id=1852</a> to complete #8-14. [The NCTM handout will maybe save time because the students can cut out the existing circle rather than drawing and cutting out their own.] The students should add this to their notes.</td>
<td></td>
</tr>
<tr>
<td>4. TEACHER or student log in on KA. Project and watch “Area of Circle” video and then do problems together. Students may do problems at their seat or on the board.</td>
<td></td>
</tr>
<tr>
<td><strong>Class Periods 4-6</strong></td>
<td>copies of Fraction Circles on colored paper if possible scissors tape white paper</td>
</tr>
<tr>
<td><strong>Area of Sectors and Arc Length</strong></td>
<td></td>
</tr>
<tr>
<td>1. Springboard, Algebra I textbook: Do 32-2 p. 467-8 #1-6, 9</td>
<td></td>
</tr>
<tr>
<td>2. TEACHER or student log in. Project and watch KA “Areas of circles and sectors” video and then do problems together. Students may do problems at their seats or on the board. Also, do at least two problems from “Arc Length” on KA.</td>
<td></td>
</tr>
<tr>
<td><strong>Class Periods 7-9</strong></td>
<td>Circle similarity handout copies</td>
</tr>
<tr>
<td><strong>Similarities with Circles</strong></td>
<td></td>
</tr>
<tr>
<td>Teacher asks:</td>
<td></td>
</tr>
<tr>
<td>1. What does it mean to be <strong>mathematically similar</strong>?</td>
<td></td>
</tr>
<tr>
<td>2. Remember the Wump family.</td>
<td></td>
</tr>
<tr>
<td>3. Display three pairs of figures. Are they mathematically similar?</td>
<td></td>
</tr>
</tbody>
</table>
The students complete the **Circle Similarity Handout** to determine if circles are proportional. If time, allow a student to log on to KA. Project and demonstrate the “Arc Length” problem set.

<table>
<thead>
<tr>
<th>Additional Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>● The teacher reminds students to sit with their groups daily for project.</td>
</tr>
<tr>
<td>● The teacher reminds groups to work together. When students raise hands to ask questions, the teacher asks the groupmates for the question. If the groupmate does not know the question, the teacher walks away.</td>
</tr>
<tr>
<td>● The teacher requires students to watch videos before answering any content questions. Remind the students to use closed captioning to read videos if they do not have earbuds.</td>
</tr>
</tbody>
</table>
Appendix G:

Circle Similarity Handout

Name:          Date:

Are circles **mathematically similar** to each other?

<table>
<thead>
<tr>
<th>Circle</th>
<th>Measure of Central Angle</th>
<th>Radius</th>
<th>Arc Length (Show calculations. <strong>Do not use 3.14</strong> for pi. Use the pi button on your calculator.)</th>
<th>Arc Length: Radius (Show calculations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If we were to add a circle 4 to the picture and table, what would its arc length be?

What would its ratio of arc length to radius be?

Are the circles **mathematically similar (proportional)** to each other? Write at least **two sentences** to explain how you know.
Appendix H:

PowerPoint Slides

Warm Up 3/14/16

1. Find the area of the regular polygon.

2. Draw an equiangular quadrilateral that is not equilateral.

Rotations

<table>
<thead>
<tr>
<th>M</th>
<th>Ms. TEACHER - 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KA- 2</td>
</tr>
<tr>
<td></td>
<td>Project - 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T</th>
<th>Ms. TEACHER - 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KA- 1</td>
</tr>
<tr>
<td></td>
<td>Project - 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block WTH</th>
<th>Ms. TEACHER - 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KA- 3</td>
</tr>
<tr>
<td></td>
<td>Project - 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F</th>
<th>Ms. TEACHER - 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KA- 1</td>
</tr>
<tr>
<td></td>
<td>Project - 2</td>
</tr>
</tbody>
</table>
Warm Up 3/15/16

* All students get your binders as usual.
* Group 1 students also get your laptop.

Warm Up:
1. What is the area of this polygon if the sides are 8 cm and the apothem is 9 cm?

2. What is the area of the trapezoid

Warm Up 3/16 or 3/17

1. Find the area of the shape:

2. Find the area of a rhombus with diagonal lengths of 25 cm and 40 cm.
Warm Up 3/18/16

1. What is the area of this circle?
2. What is the circumference of this circle?

3. Write at least 3 sentences to explain why the area of a circle is \( \pi \) times the radius squared. Refer to the picture below in your answer.

Learning Targets Day 1

Length and Area of Circles
• Develop and apply a formula for the circumference of a circle.
• Develop and apply a formula for the area of a circle.
Length and Area of Circles Day 1

1. Turn to P. 463 -464
2. Label it “Length and Area of Circles” in your notes.
3. Do # 1-5. Write answers in your notes.
4. Do # 8-14. Write answers in your notes.
5. KA “Area of Circle” Demonstration

The History of Pi  Day 1

The earliest textual evidence of pi dates back to 1900 BC; both the Babylonians and the Egyptians had a rough idea of the value. The Babylonians estimated pi to be about 25/8 (3.125), while the Egyptians estimated it to be about 256/81 (roughly 3.16). Who was the closest (the Babylonians or the Egyptians)?

From http://www.piworld.com/section/31388/article/history-of-pi.html
Learning Targets Day 2

Sectors and Arcs

• Develop and apply a formula for the area of a sector.
• Develop and apply a formula for arc length.

Sectors and Arcs Day 2

1. Turn to page 467
2. Do #1 – 6, 9. Write the answers in your notes.
3. KA demonstration “Areas of Circles and Sectors” and “Arc Length.”
## Rotations  Bell 3 April 4 - 8

<table>
<thead>
<tr>
<th></th>
<th>Ms. TEACHER - 2</th>
<th>KA- 1</th>
<th>Project - 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>Ms. TEACHER - 1</td>
<td>KA- 2</td>
<td>Project - 3</td>
</tr>
<tr>
<td>W</td>
<td>Ms. TEACHER - 3</td>
<td>KA- 1</td>
<td>Project - 2</td>
</tr>
<tr>
<td></td>
<td>Ms. TEACHER - 1</td>
<td>KA- 2</td>
<td>Project - 3</td>
</tr>
<tr>
<td>F</td>
<td>Ms. TEACHER - 3</td>
<td>KA- 1</td>
<td>Project - 2</td>
</tr>
</tbody>
</table>

## Warm Up 4/4/16

1. The radius of the circle below is 10m. If the sector is one-third the circle, what is its area?

![Diagram of a circle with a sector shaded to represent one-third of the circle.]

2. If the area of circle O is 24 square yards, what is the area of sector AOB?

![Diagram of a circle with sector AOB highlighted.]
Warm Up 4/5/16

A circle with circumference 6 has an arc with a 3/360° central angle.

What is the length of the arc?

Warm Up 4/6/16

1. Ms. TEACHER says the probability of spinning a red is 1/8, but Ms. Cargile says that it is 1/4 because there are 4 colors (red, yellow, green, and blue). Who is correct? Explain how you know.

2. What is the probability of getting a green or blue on the first spin?
Warm Up 4/8/16

These two sectors have the same area. What is the missing angle?

Day 3 Circle Similarity

1. What does it mean for figures to be mathematically similar?

Remember the Wumps?
Who were the impostors? Who is not similar?
Day 3 Circle Similarity

2. Are these quadrilaterals mathematically similar? How do you know?

3. Are these triangles mathematically similar? How do you know?
Day 3 Circle Similarity

4. Do you think the circles are mathematically similar to each other?

5. PROVE IT!

Day 3 Circle Similarity

This picture shows 3 concentric circles. Complete the table below:

<table>
<thead>
<tr>
<th>Circle</th>
<th>Measure of Central Angle</th>
<th>Radius</th>
<th>Arc Length</th>
<th>Arc Length/Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Day 3 Circle Similarity

If we were to add a circle 4 to the picture and table, what would its arc length be?

What would its ratio of arc length to radius be?

Are the circles mathematically similar (proportional) to each other? Write at least two sentences to explain how you know.

Day 3 Learning Targets

Learners will be able to prove that all circles are similar.
Appendix I:

Project

Name: _________________________________   Date: ________________ Bell: ___________

Directions: You may not move to the next section until you get signed off for the current section.

<table>
<thead>
<tr>
<th>Initials</th>
<th>Day 1</th>
<th>Part</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Draw your target with at least 3 concentric circles using a compass and at least 5 equal sectors.</td>
<td>____/16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Complete the first column of the Target Practice table. All calculations are shown.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 2</td>
<td>Complete the 2nd and 3rd columns of the Target Practice table. All calculations are shown.</td>
<td>___/ 28</td>
</tr>
<tr>
<td></td>
<td>Day 3</td>
<td>Answer 5 a, b, c, and d.</td>
<td>___/ 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Points:</td>
<td>___/ 50</td>
</tr>
</tbody>
</table>
Name: _________________________

50 Total points  Classwork Section

Target Practice due April 8th

Prompt:

In your group, each person will design and draw an identical target (same dimensions) to be used in a non-traditional game of darts. The players of the game will throw one dart at each target. Each target must:

1. Fit on one sheet of white paper.
2. Include at least 3 concentric (see below) circles:

3. Include at least 5 equal sectors. The target below only has ____ sectors.

4. Include a completed Target Practice table (below).
Area of sector formula:

$$\text{Area of a sector} = \frac{\text{Angle}}{360°} \times \pi r^2$$

Length of arc formula:

$$\text{Arc length} = 2\pi r \times \frac{\text{central angle}}{360°}$$

Target Practice (Show calculations and circle the answer) 4 pts. each

<table>
<thead>
<tr>
<th>Inner Circle (Bullesseye) Area</th>
<th>Arc Length of Inner Circle</th>
<th>Area of Sector of the Inner Circle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Ring Area</th>
<th>Arc Length of the Second Ring</th>
<th>Area of Second Ring Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third Ring Area</td>
<td>Arc Length of the Third Ring</td>
<td>Area of Third Ring Sector</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth Ring Area</td>
<td>Arc Length of the Fourth Ring</td>
<td>Area of First Fourth Sector</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Area of the Target</td>
<td>Total Circumference of the Target</td>
<td></td>
</tr>
</tbody>
</table>
5. Once everyone has completed their targets, use all of the targets to answer the following questions. Work together! **Each question is worth 3 points.**
   a. Describe which section a player is **most** likely to hit (like the bullseye or the third ring)? __________ Why? Write at least two sentences to explain your reasoning? Use book vocabulary for maximum points.

   b. Describe which section a player is **least** likely to hit (like the bullseye or the third ring)? __________ Why? Write at least two sentences to explain your reasoning? Use book vocabulary for maximum points.

   c. Targets usually have points. Each group will make your target game worth 100 points. **Write point values in each section of your target. The point values must make sense!** The hardest sections to hit must be worth more points. Explain why you assigned each point value to each section in at least 4 sentences. Use book vocabulary for maximum points.

   d. What did you learn from this project?

   e. Staple all of the targets and this handout for your group together.
Appendix J:

Khan Academy Playlists

Class, grade, and teacher: Geometry, 9th grade, TEACHER

- In order to receive full credit (50 max), you must complete the table below.
- This is due March 20 the end of the bell.

**Do You Have What it Takes to become a GEOMETRY WARRIOR**

<table>
<thead>
<tr>
<th>Module</th>
<th>Practiced (x 8)</th>
<th>Level 1 (x 12)</th>
<th>Level 2 (x 14)</th>
<th>Mastered (x16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of triangles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area of parallelograms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area of trapezoids</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area of kites</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Areas of composite figures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grand Total:

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

219
Class, grade, and teacher: Geometry, 9th grade, TEACHER

- In order to receive full credit (50 max), you must complete the table below.
- This is due April 8 the end of the bell.

Do You Have What it Takes to become a

GEOMETRY WARRIOR

<table>
<thead>
<tr>
<th>Module</th>
<th>Practiced (x 8)</th>
<th>Level 1 (x 12)</th>
<th>Level 2 (x 14)</th>
<th>Mastered (x16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius, diameter, and circumference</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area of circle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arc Measure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angles in circles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Areas of circles and sectors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arc Length</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grand Total:
**Appendix K:**

**Written Survey**

**Student Survey**

Fake name: _____________________  Birth month & day: ___________ ex. December, 14

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>No Opinion</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I’m certain I can learn the skills taught in math class this year.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>I can do almost all of the work in math class if I don’t give up.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Even if math is hard, I can learn it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>I’m certain I can figure out how to do the most difficult math work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>I can do even the hardest math if I try.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>I learn math quickly.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>In my math class, I understand even the most difficult work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>I get good grades in math.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Math is one of my best subjects.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>I am just not good at math.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>I enjoy learning math.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>I do math because I enjoy it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>I am interested in the things I learn in math class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>I look forward to my math class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Can anyone be good at math if they work hard? Explain.

2. How does doing projects make you feel about math class?

3. Which do you like better: doing math in a small group or doing math with the whole class? Why?

4. How do the points and badges on Khan Academy make you feel? Does collecting points and badges make you want to do more math? Why?

5. Do you like learning on your own on the computer and doing projects with your group instead of learning math directly from the teacher? Explain.

6. If you were the principal, would you make all the math teachers use computers, small groups, and projects to teach math? Why?

7. How would you improve the Khan Academy website if you could?
Appendix L:

Interview Protocols

Student Interview Guide:

“Hello, thank you for participating in my research study. I will first ask you some background questions. When finished, I will ask you several questions about Khan Academy, doing projects, and math class. If there are any questions that you don’t want to answer, feel free to say, ‘I don’t want to answer that.’ Do you understand? [Wait for the student to response yes or no. If no, explain further and answer any questions.] This interview is being audio recorded, and the recording will be erased once it is typed. During the interview, I will refer to you by your fake name. What fake name do you want to use? [Wait for the student to respond.]”

8. What grade are you in?

9. How did you like math last school year? Why? What grades did you get? Did you get to talk to your friends?

10. What is your favorite class this year? Why is it your favorite?

11. What class do you not like this year? Why don’t you like it? What could the teacher do to make it better?

12. Do you like math? Why or why not?

13. Are you good at math? How do you know?

14. Can anyone be good at math if they work hard? Are some people born better at math?

15. Do you know what you want to do as a career when you grow up? Why? Would you consider working in a job in a STEM field?

16. What projects have you done in math classes in the past? Which project was your favorite? What did you learn? Do you like doing projects? Do projects make you like math class more?
17. Which do you like better: working in a small group or working with the whole class?

18. Should your teacher do more small group work in class? Does it make students like math more or less? Why?

19. Do you prefer to practice doing math on the computer or with the entire class?

20. If you were a math teacher, what percent of class time would your students work on the computer? What percent of class time would be spent teaching the old-fashioned way on the board? What percent of time would be spent working on projects? Why?

21. If you could, how would you improve your current math class?

22. If you were the principal, would you make all the math teachers use computers, small groups, and projects to teach math?

23. When working on the computer, do you ever help or get help from your classmates? Do you think talking to your classmates helps you to like math better?

24. Do you like working by yourself on KA?

25. Does KA make you feel like you are better at doing math? Why or why not?

26. Do you think the other kids know how well you are doing on KA? Do you care if other kids know what topics you have mastered? Why?

27. Do you feel smarter in math this year than last year? Why or why not?

28. Have you used a computer program to learn math before this year? Which one? How do you like it?

29. Did it allow you to collect points or badges? If so, do you like them? Do they make you want to do more math to earn more points and badges?
30. When you get a point do you feel like you know more math? When you get a badge do you feel like you know more math?

31. **Do you watch the KA videos if you don’t understand something? How often?**

32. What are you favorite kinds of problems: multiple choice, fill in the blanks, or the kind when you have to move something?

33. **Do you ever do extra problems on KA that were not on your playlist?**

34. **How would you improve the KA website if you could?**

(The bold indicates questions of more significance.)
Teacher Interview Guide:

“Hello _______________. Thank you for participating in my research study. I will first ask you some background questions. When finished, I will ask you several questions about your perceptions of mathematics instruction. If there are any questions that you don’t want to answer, feel free to say, ‘I don’t want to answer that.’ Do you understand? This interview is being audio recorded. The recording will be erased once it is transcribed.”

1. Why did you decide to become a teacher?
2. What is your area of licensure?
3. What is your teaching experience? How long have you taught? What subjects? What types of settings have you taught in?
4. Do you enjoy teaching? Why or why not?
5. Do you currently use KA? Do you think it does/can help students to learn mathematics?
   a. Do you think KA motivates students to learn?
   b. Does KA make students feel more confident in their abilities to do mathematics?
6. How would you describe Project Based Learning (PBL)? What is it? Do you currently use it?
   a. What are the pros and cons of using it?
   b. About how many projects do your students do in a year? Would you like to do more? Less?
   c. Do you think it does/can help students to learn mathematics?
   d. Do you think it motivates students to learn? Why or why not?
7. How would you describe the term blended learning? What is it? Do you currently use it? Why or why not? What are the pros and cons of using it? Do you think it does/can help students to learn mathematics?
8. Do you think blended learning motivates students to learn?
9. What do you think motivates children to learn mathematics?

10. Do your students like math? About what percent would you say love it? Like it? Hate it?

11. What is the best way to teach mathematics?

12. If you had a magic wand and could create a perfect setting for teaching, what type of teaching style would you have? Would you lecture? Use nature to teach? Combine mathematics with science? The sky is the limit. What would you do?

13. Do you think the instructional model used for the study is sustainable with only one teacher in the classroom? Explain. Are there any strategies that you might continue to use?
Appendix M:

Institutional Review Board Approval

Institutional Review Board - Federalwide Assurance #00003152

University of Cincinnati

Date: 11/18/2015

From: UC IRB

To: Principal Investigator: Lori Cargile
CECH Education

Study ID: 2015-7111

Re: Study Title: Does Blended Learning with Khan Academy and Project Based Learning Impact Student Motivation to do Mathematics?

The above referenced protocol and all applicable additional documentation provided to the IRB were reviewed and APPROVED using an EXPEDITED review procedure in accordance with 45 CFR 46.110(b)(1)(see below) on 11/17/2015.

This study will be due for continuing review at least 30 days before: 11/16/2016.

The following was reviewed:

Study Documents
Checklist for PI Children Lori Cargile
Cincinnati Public Schools Research Requirements
COI Forms Lori Cargile
COPUS Classroom Observation Protocol
IRB Protocol Lori Cargile
Lori Cargile CV
Parent Consent Lori Cargile
Parent Cover Letter Lori Cargile
Student Interview Protocol
Student Survey
Teacher Interview Protocol
Youth Assent Lori Cargile

The IRB reviewer has determined that this research presents no greater than minimal risk.