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The Effect of Coding Classes on Mathematics Achievement of Preschool Students

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Walden University
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Abstract

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MS, Atilim University, 2006

BS, Istanbul Technical University, 1991

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Early Childhood Education

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Abstract

The problem that inspired this study is that Turkish students' mathematics rankings on global exams such as PISA and TIMMS had been below the average for many years, a problem that may have had roots in children's early experiences with mathematics. The purpose of this quantitative pretest posttest quasi-experimental control group study was to determine the effect of computer-programming classes with Code Studio on mathematics scores of preschool students. Siemens's connectivism theory for the digital age formed the foundation of this research. A single research question regarding the effect of computer coding classes on mathematics scores of preschool students over one academic year guided this study. Five years of mathematics scores of students who attended one of two preschools in Turkey that enrolled expatriate children were collected as secondary data. One of the preschools implemented computer programming classes with Code Studio and the other did not; computer coding classes formed the independent variable. The dependent variable, June mathematics scores of the control and experiment groups, was controlled for the covariate, September mathematics scores. An ANCOVA model was used to analyze the effect of computer programming classes with Code Studio on the mathematics abilities of preschool children. The results indicated that a statistically significant difference in mathematics growth from September to June in preschool students who were taught computer coding compared to students who were not taught computer coding. Increased mathematics achievement that might result from early coding instruction represents a positive social change that may be realized when coding instruction is adopted widely in preschool and childcare settings.

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Dedication

I dedicate this research to my family’s young generation: my daughter Savana Ece Ozden, my son Kursat Aga Erbilgin, my nieces Nusin Gegin and Nadin Gegin, and my lovely granddaughter Izabel Eliz Ozden. Be lifelong learners.

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Chapter 1: Introduction to the Study

Organization for Economic Co-operation and Development (OECD, 2020) and Trends in International Mathematics and Science Study (TIMSS, 2019) results revealed low math scores of the Turkish students, which would affect their future work performances, family life, wealth, and eventually, national economic level. OECD reports attracted attention on the need for in service teacher support workshops and low preschool attendance rate of the Turkish students. Meanwhile, Alkhawaldeh et al. (2017) highlighted the importance of revising the traditional teaching methods to meet the expectations of the young generation of the digital era.

This study was based on Siemens's (2005) connectivism learning theory. Siemens suggested that teachers should revise teaching styles to meet the needs of the digital age. Computer coding classes might be an alternative to increase math grades of preschool students. In addition, Siemens also suggested that children acquired critical thinking and problem-solving abilities through hands-on activities while they play digitally (Siemens, 2005). In this quantitative study, I focused on effects of computer-coding classes on preschool students' mathematics scores. Low mathematics knowledge of early childhood educators may lead to mathematics anxiety and a reluctance to teach the subject (Novak & Tassell, 2017). The results of this study provide an enhancement to traditional mathematics teaching and may help early childhood educators to overcome their fear of teaching mathematics and create a positive social change of a better academic future and a better life for children. In Chapter 1 of this study, I explain the focus of the problem and the need for this study. I present the guiding research question and the theoretical framework that formed the basis of this study. I begin with a description of the background of the study.

Background

The Program for the International Students Assessment test (PISA) 2015 results indicated that mathematics scores of the 15-year-old Turkish students were below the OECD average (OECD, 2020). The report indicated that educational quality, varying socio-economic status of the families, low preschool attendance were the reasons of the gap between the countries (OECD, 2020). According to the PISA 2018 report, Turkey should focus on early childhood education attendance, teacher educations, financing, and curriculum improvements. Turkish fourth grade students took another global test, the TIMSS, in 2011 and 2015 (Mullis et al., 2016). In 2011, Turkish students ranked 35th among 52 nations (Mullis, 2012), but in 2015, they ranked 36th of 49 countries (Mullis et al., 2016). Turkish government-initiated legislations regarding science, technology, engineering, and mathematics (STEM) education (Geesa et al., 2019) inspired collaboration between the Movement of Enhancing Opportunities and Improving Technology (FATIH Project) and the Ministry of National Education (MoNE) to distribute free tablet computers to public school students to improve the STEM abilities of low-income students (YEGITEK, 2016a). MoNE continues to open STEM education centers and finance STEM research, laboratories, materials, and computer programming lessons (YEGITEK, 2016a).

The early years, from birth to age 7, form a period in which the nurturing care of parents, teachers, and community members promote children’s wellbeing and their ability to learn (Britto et al., 2017). The foundation of cognitive, social, emotional, and language skills that lead to later success in life is developed during the early years (Bakken et al., 2017). Portelance et al. (2015) indicated that high-quality and early STEM experiences can improve children's cognitive and literacy growth. According to McClure et al. (2017), early learning is supported by multiple systems that are related to each other such as parents, educators, teachers, school environment, nature, and cultural activities. Teachers play a critical role in the development of STEM engagement for young learners. In-service teachers, who are enthusiastic about science and mathematics, can engage young learners to STEM-related topics. However, many early childhood teachers do not trust their knowledge of STEM subjects and therefore are reluctant to teach mathematics (Seker & Alisinanoglu, 2015).

Yin and Fitzgerald (2015) claimed that teachers need new educational tools to meet the needs of the digital era. Topcu et al. (2016) revealed that when students' attitudes towards mathematics increase, their achievement also increases. Computer programming has developmental benefits in cognitive skills building in mathematical abilities and logical thinking of preschool and early primary school age children (Strawhacker & Bers, 2018). Computer programming lessons in early childhood education might help young learners to achieve basic numeric, logical concepts and problem-solving abilities (Papadakis et al., 2016)

Problem Statement

The problem that was the focus of this study is there is no literature about the value of coding classes for preschool children in supporting mathematics achievement.

Early childhood education provides an opportunity before mandatory schooling begins in grade one when essential concepts and skills can be developed. Early mathematical understanding prior to elementary school attendance can diminish the gap between low-income students' long-term academic performance (Scalise et al., 2017). Basic early numerical skills such as identifying numbers, counting, and sorting are significant to later mathematics skills such as addition and subtraction (Siegler & Lortie-Forgues, 2014). According Outhwaite et al. (2017), implementing tablet-based mathematics lessons supported four 7-year-old students even though the children were previously low-achieving English as a Second Language (ESL) learners. Jalali and Heidari (2016) suggested that there is a relationship between learning pleasure and learning achievement; therefore, teachers must offer learning opportunities students find enjoyable. Schukajlow (2015) suggested this is especially true with mathematics learning. According to Daugherty et al. (2014), teachers can benefit from technology implementation to close the gap between low- income and high-income children's mathematical abilities. However, although León et al. (2016) found that programming with Scratch Jr. software had significant positive effects on the mathematics scores of 6th grade students, no significant improvement in mathematics ability was detected among second grade children. These authors suggested that more research is needed to determine the value of programming in early childhood for children's mathematics achievement. To fill this gap in literature, I examined the effects of coding with a free online coding tool, Code Studio (2020), on the mathematics scores of preschool students.

Purpose of the Study

The purpose of this quantitative pretest posttest quasi-experimental quantitative study was to evaluate the effect of coding classes on the classroom mathematics scores of preschool students. The dependent variable was students' mathematics scores as measured by teachers' assessments at the beginning and end of the academic terms and the independent variable was computer-coding using a free online program called Code Studio (2020) delivered to students in one preschool, but not to students in a comparable one. In this study, I intended to discover the effect coding classes have on preschool students' mathematics scores. Secondary data of preschool student report cards filled over 5 academic years were provided from each of two preschools, one of which teaches computer coding with Code Studio while the other teaches no computer coding. Data were collected from a total of 128 student report cards.

Research Questions and Hypotheses

Archival mathematics scores of the past 5 years of mathematics grades of a total of 128 students from two preschools located in Ankara, Turkey, composed the data set for this study. Mathematics grades from oral assessments given at the beginning and end of each 5 academic years were collected from the school archives. The dependent variable was classroom mathematics scores. Covariate of this study was the pretest mathematics scores of the preschool students. The independent variable was computer coding instruction, using the program Code Studio. The ordinal ratings of Excellent (E), Good Progress (G), Working on Skill (W), and Unsatisfactory (US) were recorded and then transformed to continuous data of 1 = US, 2 = W, 3 = G, 4 = E. According to Boone and Boone (2012) Likert scale 1-4 can be used to statistically evaluate grading of preschool students for this quantitative study. With this Likert scale data mean, standard deviation, and an ANCOVA test can be performed by the SPSS program for the statistical analysis of this pretest-posttest quantitative research (Boone & Boone, 2012).

One research question guided this study: Is there a statistically significant difference in mathematics growth over 1 academic year in preschool students who were taught computer coding compared to students who were not taught computer coding? The hypotheses were as below:

H_o: $\mu 1 = \mu 2$ There are no statistically significant differences in mathematics growth over 1 academic year in preschool students who were taught computer coding and students who were not taught computer coding, while controlling for the pretest scores.

H_a: $\mu 1 \neq \mu 2$ There are statistically significant differences in mathematics growth over 1 academic year between preschool students who were taught computer coding and students who were not taught computer coding, while controlling for the pretest scores.

Siemens (2005) argued that student learning styles should be updated to meet the needs of the technological improvements. Digital learning tools should be implemented in teaching that could even help preschool teachers to overcome their fear of teaching mathematics (Gresham & Burleigh, 2019). The research question of this study was based on Siemens’s theoretical framework that computer coding classes with Code Studio might help young learners to increase their mathematic grades.

Theoretical Foundation for the Study

The theoretical foundation for this study was Siemens's (2005) connectivism theory for the digital age. As knowledge continues to evolve, the ability to access information becomes more important than what is known (Siemens, 2005). Siemens suggested that students learn when they can combine their previous experiences with new challenges, and teachers should revise their teaching methods to meet the needs of the digital era (Siemens, 2005).

Siemens (2005) suggested that former learning theories such as behaviorism, cognitivism, and constructivism were based on understanding instructions and processing information as knowledge. According to Siemens, learning is supported not only by traditional methods but through technology, computers, tablets, media, group activities, practice, and personal networks. Siemens defined learning as focusing on outside knowledge and unintended connections that help to learn without specific intentions to learn. Siemens's definition of learning supports the use of coding classes with children as they learn during digital game play (Kalelioglu, 2015). According to Kalelioglu (2015), children who can code achieve higher order thinking skills, problem-solving skills, and critical thinking abilities, as well as basic numerical and shape concepts (Kalelioglu, 2015). Siemens suggested that students should learn how to reach knowledge and implement what they learned in new challenges are important aspects of learning necessary to the digital era. I describe Siemens's connectivism theory in greater detail in Chapter 2.

Nature of the Study

I conducted this study using a pretest-posttest quantitative design. Campbell and Stanley (1963) suggested that pretest-posttest designs recognize the need to evaluate the effects of maturation and nature-nurture on children in educational researches. In this research, I collected secondary data from the past 5 years of mathematics grades of two preschools' students' assessments. One of the preschools taught computer coding with Code Studio and the other school did not have coding classes in its curriculum. Both of the preschools taught in English to children of expatriot, native English speakers and to children of Turkish families. All of the parents were highly educated and aware of the importance of ESL instruction for their children and the development of children's interest and ability in STEM. Students attending these schools came from middle class or wealthy families. Students' parents were mostly from America, England, Turkey, Holland, German, Japan, China, Qatar, Saudi Arabia, India, Sweden, and Croatia. Female and male percentages were almost even. Because of the demographic profile of students enrolled in these school, data excluded low income students and Turkish students attending schools which followed the Turkish curriculum. Preschool students aged 4 to 5 are not expected yet to know how to read and write.

As an alternative to using archival data, I considered monitoring students' academic improvement during 1 academic year from September to June, but I decided that the need for parental consent and student assent would likely result in fewer data points than archival data. Also, because these schools were small, sample sizes generated from a single academic year would be too small and would not meet the minimum

GPower 3.1 (Faul et al., 2007) total sample size is calculated as 128 with an ANCOVA of two groups effect size and a 0.05 alpha error probability.

I expected that by comparing the archival data collected from the past 5 years of enrollment of both schools, I would be able evalute the effects of coding classes on the mathematics scores of the preschool students aged 4 to 5.

Definitions

Critical thinking: Critical thinking is the ability to observe, analyze, and interpret data for solving problems (McPeck, 2016).

Code Studio: Code Studio is a non-profit programming application that aims to teach coding to children, women, and minorities (Code Studio, 2020).

Coding: Coding refers to a list of instructions that tell computers what to do (Barbarosa et al., 2018).

Computational thinking: Computational thinking is a set of thinking skills, approaches, and attitudes that help solving problems from a scientist's perspective (Sung et al. 2017).

Computer literacy: Computer literacy refers to the set of skills that help individuals to benefit from technology in information access and producing new games, applications, and projects (Institute of Education Sciences, n.d.).

Problem solving: Problem solving is the ability to identify problems, make learning plans, set goals, and interpret outcomes to reach new goals (Nurdyansyah et al., 2017).

Assumptions

In this study, I assumed that teachers in both schools had the same teaching and oral assessment abilities. I also assumed that teachers in the preschool that taught coding followed the Code Studio computer programming lessons faithfully and that teachers in the preschool that did not teach coding in fact did not teach coding. I assumed that teachers' assessments of children's mathematics skills were accurate and free from bias.

Scope and Delimitations

The scope of this study involved two preschools from Ankara, Turkey, and the comparison of mathematics scores of preschool children enrolled in these schools, one of which taught computer programming to preschoolers and one of which did not. This study was delimited to include only children ages 4 to 5, who were native English speakers from expatriate families, and English-speaking children of Turkish families, and who attended these two preschools. Excluded from this study were older and younger students who attended the two schools and students who attended other preschools in Turkey.

Limitations

One of the limitations of this pretest posttest quasi-experimental study was lack of random preschool assignment because the control and experiment groups were formed out of two preschools with similar education systems, parent-student profiles, and locations (Campbell & Stanley, 1963). Students came from different countries; therefore, English was not the mother tongue for many children. In addition, they did not know how to read and write, hence students depended on their teachers' instructions. Parents of children in this study were highly educated, and economic backgrounds were mostly similar. This study took place in Ankara, Turkey; therefore, the results might be different in other places of the world. In addition, schools followed the British Early Years Foundation program, and therefore did not reflect the Turkish national curriculum. Another limitation of this study was although the curriculum was the same in both schools, teachers were different, so I assumed the oral assessments were applied in the same way in both schools and free of bias (Campbell & Stanley, 1963).

Significance

In this study, I compared the archived mathematics grades of the last 5 years of the preschool students, half of whom attended a school that included coding classes as part of the curriculum and half of whom attended a school that did have coding classes. The research results indicated a statistically significant positive effect of coding classes on students' mathematics success. Novak and Tassell (2017) found that lower mathematics knowledge of early childhood educators can lead to higher mathematics anxiety and reluctance to teach mathematics, and suggested that a computer-based program of instruction might relieve teachers of the task of teaching mathematics and may result in greater mathematics ability in preschool children. Therefore, the results of this study suggest an adjunct to traditional mathematics teaching and may help early childhood educators overcome their fear of teaching mathematics. This study contributed to knowledge about early mathematics instruction and may lead to positive social change regarding children's mathematics achievement.

Summary

Although the Turkish government has made various efforts to improve the mathematics skills of Turkish students, global rankings suggest otherwise (MoNE, 2016). Early childhood education teachers may be reluctant to teach mathematics because they do not trust their knowledge. Meanwhile, young learners enjoy spending time with computer games, applications, and digital programs. Therefore, in this study I intended to determine if computer-programming classes with Code Studio had a positive effect on mathematics scores of preschool students. In Chapter 2, I present a literature review on the benefits of teaching technology to young learners, computer programming with various applications, teachers' reluctance to teach mathematics, and Siemens's (2005) learning theory for the digital age.

Chapter 2: Literature Review

The purpose of this quantitative pretest posttest study was to evaluate the effect of coding classes on the classroom mathematics scores of preschool students. Siemens's (2005) connectivism theory for the digital age provided the foundation of this study. Although there has been a lot of research about computer programming with older students, there was a gap in the literature on the effects of computer programming on mathematics scores in early childhood educational settings (Moreno-Leon & Robles, 2015; Portelance et al., 2015; Strawhacker et al., 2015). In this chapter, I present the literature search strategy, more detail about the study theoretical framework, and literature relevant to the purpose of this study, including Turkish students' global ranking in the PISA tests, the FATIH project, the Turkish government's STEM curriculum implementations, early childhood education teachers' mathematics anxiety, benefits of young children's technology engagement, computer programming applications, and the programming tool Code Studio.

Literature Search Strategy

I conducted a literature search using scholarly databases to find peer-reviewed articles relevant to my study. I used educational databases such as ERIC, ProQuest, Education Source, and SAGE. The keywords in my research included *computer programming, early childhood education, critical thinking, teachers' math anxiety, math teaching reluctance, FATIH Project, Siemens' digital learning theory, effects of technology on early learners, STEM in the early childhood education*, and *Code Studio*. I used Google Scholar as well as the Walden University library to get access to peer reviewed articles published in scholarly journals. My research was a quantitative study, but I researched both qualitative and quantitative studies to support my research. Although, computer programming is an appealing subject, there was a lack of publication on the effects of programming with Code Studio, but much research on another programming tool called Scratch.

Theoretical Foundation

The theoretical foundation of this study was based on Siemens's (2005) connectivism learning theory for the digital age. Although behaviorism, cognitivism, and constructivism theories were widely used in learning, Siemens claimed that given the impacts of technology, learning styles and theories should be revised. Traditional learning theories such as behaviorism (Watson, 1930), constructivism (Piaget, 1948; Vygotsky, 1962), and cognitivism (Bandura, 1986) explain the learning styles, however these theories do not mention the effects of technology on the knowledge achievement process.

Behaviorism theory, which is one of the oldest learning theories, focuses on learning as a change in behavior through positive stimulus-response pattern (Watson, 1930). In the middle of the 20th century, researchers concentrated on brain activities that led to the formation of the cognitive learning theory, which is based on learning types or forms of acquiring, implementing, and storing information (Illeris, 2007). By the end of the 20th century, with the introduction of Vygotsky's (1962) and Piaget's (1948) constructivism theories, learning shifted from teacher-based instruction to instruction centers focused on guiding students in constructing knowledge based on their interaction within their social environment (Ashworth et al., 2004). The increasing opportunities provided by the information and communication technologies (ICT) echoed this shift, in that students can access knowledge online and prefer to share what they learned with others so that others can build on these and form their projects (Siemens, 2005).

Siemens (2008) claimed that schools used to be the place of formal instruction in the 19th and 20th centuries; however, with the technology improvements, students prefer to construct knowledge in their classes in the 21st century. Mirzaei et al. (2017) claimed that connectivism is the revised version of the previous learning theories to meet the needs of the technology era. Teachers' role changed from the person who is the main source of knowledge to the mentor who encourages research in the connectivism learning theory (Kashefi et al., 2017). Mathematics teaching shifted from classical patterns of memorization and repetition to hands-on activities, data collections, and observations (Cheng, 2015).

Bouton, Tal, and Asterhan (2021) suggested that peer network is an important component of a technology-based interactive learning. Hendricks (2019) assumed that learners might divert their knowledge achievement style to online networks and the focus on teachers' abilities might decrease in the future. Putjorn et al. (2017) claimed that technology-based teaching was the most popular method among young underprivileged Thai students in their research. Regardless of cultural, social, and financial backgrounds, teachers do not have any problems in engaging young learners with the technology implemented classes (Vas et al., 2018).

According to Siemens (2005), learning is the ability to make connections of information nodes that leads to sharing ones' project rather than building on individual experiences. Depending on the ability to transfer knowledge online with the technological reforms, learners do not need to experience everything by themselves. Learners can find ways to connect their own knowledge to others' experiences (Vas et al., 2018). Therefore, making connections is more important than the knowledge itself (Siemens, 2005). Learners are defined as nodes in a network of individuals who have access to others' data (Hendricks, 2019). Learning is assumed as a cycle that provides the learners the chance to connect, find information, update their work, publish, and improve with the feedback that they get online (Hendricks, 2019). Sharing and publication are features of the block-based online free computer coding application, Scratch Jr. Scratch Jr. is more commonly used than Code Studio because Scratch Jr. users can share their work online so that others can build on their programming experience (McClure et al., 2017).

Borna and Fouladchang (2018) researched the effects of Siemens's (2005) connectivism theory for the digital age in teaching English to non-native speakers and found that students benefitted more from the connectivism teaching method than the more traditional teacher-based communicative teaching method. Researchers claimed that students were more engaged and had increased self-efficiency through social interactions provided by the connectivism method (Borna & Fouladchang, 2018). Students formed virtual networks and shared their knowledge through online platforms that helped them achieve self-efficacy (Siemens, 2008).

Siemens (2008) suggested that connectivism learning theory could help instructors shift from the traditional teacher centered book and memorization-based learning to learner centered research-based education. Students can take control of their learning by researching, producing models, sharing them online, and achieving peer comments to improve their learning within a network of pupils (Siemens, 2008). According to Prensky (2001), teachers claimed that students may have shorter attention spans, but traditional teaching methods do not motivate students of the digital age anymore. Prensky further suggested that game-based learning might be a better teaching method to engage these digital natives who communicate, play, and reach knowledge online.

Siemens's (2005) connectivism learning theory for the digital age served as the theoretical framework of this study. I developed my research question and designed a quantitative study to collect secondary data from the archives of two preschools that followed the same curriculum, with the single difference of coding classes present in one preschool. In the review of literature related to key variables and concepts, I explain the Turkish education system and students' mathematics level in the global assessments and the governments' efforts to increase Turkish students' level. In addition, I compare the most common computer programming tools and synthesize research on how Code Studio might help early childhood teachers to overcome their fears of teaching mathematics.

Literature Related to Key Variables and Concepts

Turkish Educational System

After the establishment of the Turkish Republic, the Law on Unification of Education was announced in 1924 (Carlson et al., 2007). With this law, a new Western educational system was established, and all of the schools were gathered under the roof of the MoNE of the Turkish Republic following the same national curriculum (Koseleci, 2015). Mandatory primary education is free to every child living on Turkish soil, regardless of race, ethnicity, and gender since the establishment of MoNE.

The acting government chosen by the majority of the votes of the Turkish people, the Justice and Development Party, changed the national curriculums and mandatory education years from 5 to 12 years in order to reach 100% of school age children and more academic success since 1970 (Koseleci, 2015). Increased access to schooling was considered to be the way to get access to the European Union (EU) that would lead to economic and social development (Dulger, 2004). According to Hanushek and Woessmann (2008), research indicates that student achievement effects economic growth of countries. Therefore, the Turkish government accepted the World Bank financial loans that helped to cover the expanses of new infrastructure, teacher, and material maintenance of the disadvantaged sections (Dulger, 2004).

Turkey has seven administrative regions called Marmara, Aegean, Central Anatolia, Black Sea, Eastern Anatolia, South-Eastern Anatolia, and Mediterranean. The four western regions, Marmara, Aegean, Central Anatolia, and Mediterranean, are more socio-economically developed than the three mostly rural eastern regions, Black Sea, Eastern Anatolia, and South-Eastern Anatolia. Unfortunately, the Turkish government could not provide the same opportunities to all regions since the establishment of the republic (Tansel, 2015). The 2008 Demographic and Health Survey revealed that 73% of Kurdish children, 35% of Arabic children, and only 10% of Turkish children live in the least developed eastern parts of the country, which have the least schooling opportunities due to availability and distance to school (Kirdar, 2009). Tansel (2015) also suggested that school attendance was highly related to household income and parents' educational and cultural background.

The quality of education has been a concern of policy makers since the early 2000s; therefore, the acting government, the Justice and Development Party, publishes legislations on curriculum and pedagogical reforms and efforts to integrate information and communications technology into classrooms (Koseleci, 2015). According to Oren (2017), Turkey's future economic growth, productivity, and global competitiveness depend on a highly educated, technically improved youth. Therefore, a new student-centered rather than a teacher-centered didactic primary and secondary school Turkish national core curriculum model was introduced by the MoNE in 2004 (Dincer, 2015). The new constructivist curriculum model focused on shifting teacher-centered learning to a student-centered system in order to get in line with the EU countries (Aksit, 2007). Thus, with this new curriculum, the Turkish national curriculum switched from a behaviorist to a constructivist educational system, and the new curriculum was based on thematic units (Dincer, 2015). Dincer (2015) also suggested that students' success was evaluated by formative assessments and results were recorded. Updated curriculum focuses on critical thinking, problem solving abilities, creativity, and social and emotional wellbeing of the children and started with the 2005-2006 academic year (Baran et al., 2016). The Movement to Increase Opportunities and Technology (FATIH) project started with the aim of providing tablets to every student, equipping schools with Internet and interactive whiteboards in order to make a technology reform in education (Yavuzalp et al., 2015).

Turkey has been evaluating students' performance by international learning assessments TIMSS and PISA tests for over the last 20 years because there are no national tests to assess the academic level of the students (Dincer, 2015). PISA tests, which are given in reading, mathematical, and scientific literacy to 15-year-old students, are repeated every 3 years (Uysal, 2015). Uysal (2015) also suggested that the difference between PISA and TIMSS tests is TIMSS evaluates what teacher should teach and the level of students' achievement; meanwhile, PISA tests focus on how students apply their knowledge on real-life situations. Turkish students first attended the TIMSS 2009 tests, which assessed mathematics and science achievement of fourth and eighth graders every 4 years (Uysal, 2015). Turkey has participated the PISA tests, which evaluate the level of OECD countries since 2003 (Kabasakal et al., 2017).

Global Rankings of Turkish Students

TIMSS is an international set of assessment that evaluates mathematics, science, and reading levels of students from 70 countries (TIMSS, 2019). The first TIMSS tests were conducted in 1995, and Turkish fourth and eighth grade students have been taking these tests every 4 years since then. Test results and countries' global rankings help policy makers take evidence-based precautions in mathematics and science teaching and learning (TIMSS, 2019). Turkish students' mathematics scores were almost 200 points below the top scoring countries such as Singapore, Hong Kong, Japan, China, and Korea (TIMSS, 2019). Mullis et al. (2016) suggested that TIMSS global rankings might assist countries in improving educational policies that could lead to higher student achievement, interest, attitudes towards STEM subjects, and better teaching staff recruitment. Turkey is one of the higher achieving countries since the 2011 tests (TIMSS, 2019). Although policy makers develop curriculum updates, the test results proved that they are not enough to increase the Turkish students' global ranking.

Program for the International Student Assessment (PISA) is another global evaluation system organized by OECD for 15-year-old students. PISA tests have been conducted every 3 years since 2000 (OECD, 2015). As of 2012, 65 countries have participated in PISA (OECD, 2015). PISA tests concentrate on reading, mathematical and scientific literacy, and how students can interpret their knowledge into their daily lives (Koseleci, 2015). Also, PISA tests differ from IEA tests in assessing students' social well-being and decision-making abilities (Koseleci, 2015). Schleicher (2007) suggested that PISA test results help countries cultivate equality, success, and productivity in education, leading to overall better scores in the global tests. Governments aim to raise students who are critical thinkers and have increased social abilities, good team workers to help their country take place worldwide; therefore, PISA tests help policymakers evaluate their students' place globally (Anderson et al., 2007).

Turkey has been participating in the PISA surveys since 2003 (Demir, 2018). The focus of the PISA 2012 tests was mathematics literacy (OECD, 2015). The results indicated that 8th grade Turkish students' mathematics performance ranked 44th, which was below the average of the participating 65 OECD countries, but there was a slight increase in the scores (OECD, 2015). Meanwhile, English students ranked 15th in the PISA 2012 (OECD, 2015). PISA 2015 tests math scores and rankings dropped to 52nd among 73 countries (OECD, 2017). These scores indicated a need to identify the problems in the Turkish educational system and take precautions to improve students' academic abilities (Demir, 2018). Student-centered learning, teacher training programs, curriculum updates, ICT-enhanced classrooms, and educational renovations are crucial to achieve a better level in the global arena (Deng & Gopinathan, 2016).

FAITH Project and STEM Curriculum Implementation

OECD reports reveal that most developed countries, which perform above the average in the global academic achievement tests, allocate funds to education projects to provide high-quality education to children all around the country (Misirli, 2015). Meanwhile, the Turkish educational system suffers from inadequate funding for teaching equipment, supply, lack of ongoing teacher education, less early childhood attendance, high dropout rates, memorization-based, teacher-oriented education, and low university placement rates (Ocal, 2017). PISA student performance reports indicated that the computer per student ratio was 0.2, Turkish students' IT access ranked one of the lowest among the other participating countries (OECD, 2020). MoNE designed 32 projects which aimed to improve technology in the Turkish Education System (Topuz & Goktas,

2015) and decided to implement The Movement to Enhance Opportunities and Improve Technology (FATIH) project, which is led by General Directorate of Innovation and Educational Technologies, Ministry of National Education (YEGITEK, 2016a). FATIH project started by distributing tablets to secondary school students, especially among underprivileged parts of Turkey, in November 2010 (Basak & Ayvacı, 2017).

Turkey allocated 1.7 billion US dollars to the FATIH Project to equip schools with network infrastructure, interactive whiteboards, tablets for each child and teacher, and the opportunity to reach educational materials online without printed books starting from the rural sections of the country (YEGITEK, 2016a). The main goal of the FATIH Project is to maintain equal access to educational resources and engage children with technology regardless of their social, economic, and cultural backgrounds to close the digital gap (YEGITEK, 2016b). The rationale behind the FATIH project was based on the assumption that by raising digital natives and providing easy access to knowledge, the project can foster cultural development, social integration, and global achievements (YEGITEK, 2016a). It was hoped that the FATIH project might help Turkey to achieve a place in the information society by reaching young learners (YEGITEK, 2016b).

Five principles of the FATIH project are (1) students have online access to information such as course notes, homework, and projects, (2) student online productivity is supported by development-oriented digital environments, (3) technology and online access are provided equally to all students, (4) project results are measured using accurate assessments, and (5) the quality of educational materials provided to support technology and online learning is high (YEGITEK, 2016a). The goals of the FATIH project were to build technology, hardware, software, and network infrastructure to all schools, provide tablets to all stakeholders, and educate teachers in technology (YEGITEK, 2016a). It was hoped that students would gain entrepreneurship skills to help them compete with the world economy through domestic production (YEGITEK, 2016a). The FATIH project was designed to minimize the gap between students by providing equal opportunities and the highest education quality with the help of technology implementation (YEGITEK, 2016a). Interactive whiteboards and tablet computers have been distributed as a part of FATIH project since November 2010 (Topuz & Goktas, 2015). An educational informatics network was also developed as part of the project and provided access to educational materials to teachers without printing expense.

STEM underlines the importance of technology in new-age learning processes and FATIH project took the very first step by providing technology to students, especially to those who could not afford computers, tablets, smart phones, or internet access (YEGITEK, 2016b). The STEM Education Report (2016) summarized how FATIH project supports STEM curriculum implementations. The technological content provided within FATIH project can facilitate the implementation of STEM instruction by supplying tools that help students in researching, applying critical thinking and discovering new ideas and applications (Corlu & Aydin, 2016). The virtual environment that FATIH project provides reduces dependency on the ability of STEM-subjects instructors, by providing access to advanced content and to inquiry-based methods (Corlu & Aydin, 2016). The FATIH project also increases in-class usage of multimedia and digital materials, which are also supported by STEM model (YEGITEK, 2016b). STEM report attracts attention on the importance of teaching coding to children starting from the kindergarten level, however, there has not been any steps taken yet (YEGITEK, 2016b).

Preschool Mathematics in Turkey

In Turkey, early childhood education has not been considered an essential step to improve students' mathematics abilities, and preschool education is not mandatory (Goksoy, 2017). Early years assessment is a crucial step to evaluate children's improvements and growth during the initial education process; therefore, parents and teachers need to track children's educational continuum to make the process better and efficient (McLachlan et al., 2018). There is no assessment strategy administered by authorities for early childhood education to develop a better mathematics education system (Bagcı & Ivrendi, 2016; Ocal, 2017). Turkish Early Childhood Education Curriculum was revised in 2013 in response to feedback on the 2006 Early Childhood Education Curriculum (OECD) (2017). In 2016, the Ministry of National Education published a handbook about child education and development focused on preschool education (MoNE, 2016). The main aim of preschool mathematics education is to improve children's cognitive skills and create positive attitudes towards mathematics (MoNE, 2016). Moreover, mathematics teaching strategies help children develop a link between their previous notional knowledge and new content to encourage them to question mathematical concepts (MoNE, 2016). The activities based on shapes, colors, sizes, and basic subjects teach mathematical concepts like pattern recognition, addition and subtraction operations, and problem-solving for kindergarten mathematics education (MoNE, 2016).

The preschools that focused on this study follow the Early Years Foundation Stage (EYFS) curriculum, which was introduced in England in 2006 to standardize and improve the learning process and childcare for children from birth to 5 years old. Although other schools, either in the UK or other countries, can apply the EYFS by choice, all preschools, childminders, and nurseries must follow the EYSF in England, so the EYFS standards apply to all schools in England (EYFS, 2017). Office for Standards in Education carries out inspections in English preschools and notes the quality and process of the EYFS (2017). Following the EYFS curriculum, children's capacity can be extended with the help of the correct teaching strategies that aim to support their curiosity and enthusiasm in literacy, mathematics, understanding of the world, and arts (Cotton, 2018).

Educational programs that follow the EYFS must provide opportunities to improve children's understanding of shapes, spaces, and numbers (EYFS, 2017). Also, counting skills and problem-solving abilities with essential addition and subtraction operations are supported by EYFS (2017). According to the Department for Education (EYFS, 2017), young children should identify numbers, count with numerals from 1 to 20, and recognize and name shapes, patterns, and quantities, before they start elementary school. In addition to basic mathematics numeracy and vocabulary, early mathematics education includes the mastery of magnitude, distance, time, and position identification (EYFS, 2017).

In this study, both preschools followed the EFYS program, although they were located in Turkey, and conformed to EFYS teaching goals, curriculum requirements, and oral assessments. Teachers used games, worksheets, flashcards, visual, hands-on touch-based tools, and manipulative toys to teach mathematical concepts and improve young learners' problem solving and critical thinking abilities (Jacobi-Vessels et al., 2016). All teachers used the same assessment guide prepared by the EYFS, asked students the same questions individually, and noted their answers for future letter gradings in both preschools. The school administrations kept records. Teachers first assessed the level of student knowledge when preschoolers started school in September and then made two assessments to evaluate student achievements throughout the academic term. Teachers set mathematics skills in counting from 1 to 20, identifying numbers from 1to 20 randomly, identifying nine basic shapes and ten colors, and performing simple additions and subtractions with fingers or objects. Teachers graded students who identified numerals 1 to 20 and beyond as Excellent, who identified numerals 1 to 15 with a few mistakes as Good, and those who did not identify numerals 1 to 15 as Working on Skill. One of the preschools in this study implemented coding classes using Code Studio as part of its curriculum, but its effect on children's mathematics ability was unknown. Among middle school students, Berland and Wilensky (2015) found computer programming was associated with a positive relationship between computational thinking and analytical thinking, which is the foundation of mathematical problem-solving ability. Computer programming increases critical thinking abilities among young learners and helps them achieve numeric sense, analytic thinking, and problem-solving skills (Sung et al., 2017). Sung et al. (2017) studied the effects of programming with Scratch Jr. on the thinking abilities of 66 kindergarten and first-grade students in the United States. They found that hands-on programming led to greater student engagement and improved learning outcomes in mathematics. The effects of coding classes with Code Studio on the mathematics abilities of the preschool students were the focus of this study.

Early Childhood Education Teachers' Reluctance to Teach Mathematics

Preschool is the very first step of the education of young children. During these early years, basic arithmetical concepts such as numbers, comparisons, addition, subtraction, and basic measurements are taught (Kiwanuka et al., 2017). Early childhood education (ECE) can help build the base for future achievements such as skills development, social and emotional well-being, and learning (OECD, 2017). Although the early mathematics curriculum is primary, Gresham and Burleigh (2019) found that early childhood teachers experienced math anxiety due to their lack of confidence in their knowledge. Math anxiety is the euphemistic phrase for negative feelings about mathematics and lack of self-confidence and test stress (Hill et al., 2016). Research indicated that math anxiety is rooted in fear of failure and general test anxiety, affecting student success and is exacerbated by anxious parents and unconfident teachers (Foley et al., 2017). According to Ramirez et al. (2018), student attitudes towards mathematics were affected by teacher anxiety levels. Teacher mindsets influence their voice and the pace of the lesson; hence students can perceive the tension of their teacher (Ramirez et al., 2018). Early childhood teachers who have math anxiety rely on traditional teaching methods, such as whole class teaching with the same textbook, flashcards, and worksheets, and focusing on curriculum expectations rather than individual student learning (Gresham, 2018). According to Beilock and Maloney (2015), teacher reluctance to teach mathematics also negatively affects transition to STEM education. Young learners often have positive attitudes towards mathematics and developing mathematics anxiety is not the frequent case for them unless they have faced adverse incidents related to mathematics (Kiwanuka et al., 2017).

Turkish students below-average scores in the PISA and TIMSS global tests raised questions about teachers' mathematics success and the undergraduate education they received before they started teaching (Ihtiyaroglu, 2018). Stein and Stein (2016) claimed that students with low academic achievement prefer teaching positions easily accessible with undergraduate education; therefore, generalist teachers, including early childhood teachers, are unprepared to teach STEM subjects. However, teaching demands knowledge, creativity, courage, and the ability to inspire and motivate learners and other professional skills (Ihtiyaroglu, 2018).

STEM education is based on student-centered learning activities that enable increased planning, critical thinking, problem-solving, and evaluation skills (Corlu & Aydin, 2016). Child-centered, interactive activities such as technology implementation enhance learning by extending the focus time, engagement, and attention of young learners (Kermani & Aldemir, 2015). Therefore, technology-based learning helps young learners to learn by doing and transform knowledge into new inventions (YEGITEK, 2016b). Turkish Industry and Business Association (TUSIAD) (2017) attracted attention to the need for STEM education to close the technology, innovation, research, production, and workforce gap. Meanwhile, the teacher's role in technology-based STEM learning is to help students achieve critical thinking abilities through hands-on activities that lead to innovations, development, and production (YEGITEK, 2016b).

Educational Benefits of Technology Engagement of Children

Capable teachers maintain their students' attention and create an interactive teaching environment (Wardlow, 2016). Engaged students actively construct, analyze, and compare data, and then apply that knowledge to new applications and technology is a crucial tool for engaging students in rich learning experiences (Wardlow, 2016). Given the rapid improvements in technology, game-based applications and computer coding programs are easily accessible for children and families (Arnott, 2017). Clements and Sarama (2016) emphasized the importance of free play and how young children during play explore patterns, shapes, and spatial relations, compare magnitudes and count objects, which are the foundations of mathematics. Marsh et al. (2016) suggested that the nature of play in the digital age has changed in terms of the resources available to children. Computer-assisted teaching in early childhood education can engage young learners in play-based learning in a digital framework and help teachers supporting children's mathematics learning (Papadakis et al., 2018). Schacter and Jo (2017) showed that preschool students taught by a Math Shelf mathematics application performed better than peers who were acquainted with traditional methods.

Regardless of economic and educational backgrounds, children are exposed to various forms of technology, such as smartphones, tablets, computers, televisions, and interactive whiteboards in their daily lives (Basak & Ayvacı, 2017). Smith (2016) suggested that all students from kindergarten to grade 12 should become digital citizens and achieve computational thinking abilities to become creators of technology, not just consumers. Kara and Cagiltay (2017) claimed that digital games encourage visual learning, enhance concentration ability, improve cognitive skills, and support children's self-confidence. Alkhawaldeh et al. (2017) found some teachers in Jordan preferred digital games over traditional teaching materials because digital games are motivating, interactive, and offer colorful graphics, and children performed better when taught with digital tools than they did when taught only by traditional methods.

In a high-quality early childhood education setting, the foundation of early literacy, mathematics, science, and computer science learning should be formed for later academic achievement (Marsh et al., 2016). Children learn about sequence through early literacy and mathematics, including concepts such as beginning, end, shortest, tallest, first, second, third, and so on, through daily play-based activities (Marsh et al., 2016). These basic sequencing abilities form the foundation of coding algorithms, which are the sets of instructions that computers follow to accomplish a specific task (Marsh et al., 2016). Teachers can guide young learners to be aware of basic sequencing through play-based coding tasks and help them write their coding sentences with the help of block-based coding programs (Marsh et al., 2016). Children can also work in groups, supporting collaboration and extending ideas by sharing (Siemens, 2005). Digital games can help teachers reinforce some mathematics topics such as comparing, constructing, dissecting, and analyzing, using visual tools through interactive choices (Mulyono, 2017).

Working with peers can also guide the learning process within and outside the classroom play activities (Mulyono, 2017). Wardlow (2016) suggested that children reveal their creativity within a given digital network and support each other to improve their projects. Several studies on the effects of active learning strategies in developing positive attitudes towards learning new things, applying critical thinking skills, and persisting in learning challenges; decreased distraction; and increased academic performance (Jensen et al., 2015; Lumpkin et al., 2015). De Witte et al. (2015) found technology implementation in early childhood education improved children’s cognitive and linguistic capacities. Hence, in this study, it was reasonable to determine whether computer programming in preschool had positive effects on young learners’ mathematics abilities that could lead to future academic success (see Papadakis et al., 2018).

Computer Programming with Code Studio

Although coding seems to be complicated, it is nothing but a new language that makes it possible to communicate with computers (Bers, 2018). Coding is a tool to teach computational thinking (Sáez-López et al., 2016). Effective teachers can use coding to plan play-based digital learning lessons that are both child-centered and teacher-led so that children can be creative, plan, and take risks through digital activities (Bers, 2018). Coding, which is the digital literacy of the technology era, should be taught in the early childhood settings through hands-on, play-based activities to engage students (Campbell & Walsh, 2017). Children born into the digital era have high potency to adopt technology into their lives, and coding is the path to digital literacy (Campbell & Walsh, 2017).

Computational thinking, which can formulate problems and solutions with an algorithmic perspective, is the primary learning outcome of coding (Campbell & Walsh, 2017). Children who have gained computational thinking can divide big problems into small ones; decomposition ability provides confidence for solving complex problems that resemble mathematical thinking (Bers, 2018). Campbell and Walsh (2017) suggested that teachers could implement computational thinking with coding activities into their formal education plans in their research study and provided positive feedback on preschoolers learning in mathematics, science, literature, and art subjects. However, as it is enacted in the professional realm, computer programming, with digital communication sentences and algorithms, is not accessible to young children, making visual programming strategies, with moving blocks, the preferred mechanism for coding by young children (Sáez-López et al., 2016). Moving blocks backward and forward and up and down are interactive coding that helps children create links between computational thinking, logic, and game production (Sáez-López et al., 2016). Scratch Jr. and Code Studio are the most popular computer programming platforms for children, connecting logic and computational thinking (Ching et al., 2018).

Code.org is a non-profit organization that focuses on teaching computer programming through a string of clicking commands and then dragging blocks to students (Kaplancalı & Demirkol, 2017). Code Studio has a user-friendly interface that lets teachers and parents follow student progress step by step when they log in to each child’s account (Kalelioglu, 2015). The explicit instructions enable student-and-teacher group work while giving directions and assigning tasks and the Code Studio program (Kaplancalı & Demirkol, 2017). Learners get new instructions when they complete a task set for them during their digital gameplay (Ching et al., 2018). Code Studio has a partnership with Disney, famous animated figures like Elsa from *Frozen* and Ralph from *Wreck-It Ralph*; children who recognize animated characters and movie universes find Code Studio attractive (Ching et al., 2018). Code Studio has a progressive structure with levels of gradually increasing difficulty, so students work in a dynamic environment with positive feedback at the end of each group. Also, as part of the experience, students can display the JavaScript code that works behind their visual coding workplace (Kalelioglu, 2015).

Code Studio and Scratch Jr. compete for attention from student users and teachers. Code Studio does not provide peer networking, enabling collaborative improvement of programming projects, as Scratch does (Kalelioglu, 2015). Scratch Jr. is more popular than Code Studio among older students because it allows students more freedom for their creativity (Codespeak, n.d). However, Code Studio is open-ended, so both beginners and more experienced users can work at their level, making it more suitable than Scratch for groups of mixed-ability users (Ching et al., 2018). Scratch Jr. does not have the progressive structure Code Studio offers. Unlike Code Studio, all code blocks are open for every user, inspiring children with coding experience but overwhelming for novices (Ching et al., 2018). Scratch Jr. makes it possible for children’s creations to be personalized by uploading and editing photos or avatars, a feature Code Studio lacks. Yet, unlike Code Studio, Scratch does not provide an answer key for teachers because of its open-ended nature, making it difficult for adults who have little coding experience themselves to help children or troubleshoot problems (Codespeak, n.d.; Kalelioglu et al., 2014). In sum, Scratch Jr. might be a more robust coding choice for coding-savvy teachers of elementary-grade students. Still, several factors make Code Studio more appropriate for preschool children and their teachers.

Coding is the new universal language and ever more essential as the digital age keeps evolving (Bers, 2018). Children can master mathematics concepts, apply logic, and use their creativity. Simultaneously, they code using visual platforms like Code Studio and Scratch Jr. Young learners use their imagination to solve problems when they program computers to perform their commands (Kalelioglu, 2015). Coding is the key to teaching children how to think rather than consider (Ching et al., 2018).

Summary and Conclusions

My purpose in the current study was to evaluate the effect of coding classes on the classroom mathematics scores of preschool students. Even though there are many articles about the benefits of coding for younger children, there was no research about how coding with Code Studio affects preschool children's mathematics achievement. Siemens' connectivism theory provides the foundation of this study. In this literature review, I described Turkey's education system, the FATIH Project and its connection to the STEM education model, teacher mathematics anxiety, which may affect preschool mathematics instruction and student performance, the value of digital materials for educational purposes, and the feasibility of learning computer programming at an early age by using online platforms like Code Studio. In Chapter 3, I present the method by which I conducted my study, describing a pretest posttest quasi-experimental comparison of mathematics achievement in two Turkish preschools that differed in their use of coding as support to mathematics learning. By this method, I filled the gap in the literature regarding the effect of coding classes on preschool children’s mathematics performance.

Chapter 3: Research Method

The purpose of this quantitative pretest posttest quasi-experimental study was to evaluate the effect of coding classes on the classroom mathematics scores of preschool students. In this chapter, I present the research design and rationale, the role of the researcher, the study methodology, issues of trustworthiness and ethics, and a summary.

Research Design and Rationale

In this study, the dependent variable was mathematics scores of preschool students after the programming classes and the independent variable was teaching of coding classes with the Code Studio program. Covariate of this study was the pretest mathematics scores of the preschool students. One research question guided this research: Is there a statistically significant difference in mathematics growth over one academic year in preschool students who were taught computer coding compared to students who were not taught computer coding? The hypotheses were as below:

H_o: $\mu 1 = \mu 2$ There is no statistically significant difference in mathematics growth over 1 academic year in preschool students who were taught computer coding and students who were not taught computer coding, while controlling for the pretest scores.

H_a: $\mu 1 \neq \mu 2$ There is a statistically significant difference in mathematics growths over 1 academic year between preschool students who were taught computer coding and students who were not taught computer coding, while controlling for the pretest scores.

According to Barnham (2015), quantitative research provides hard data that could be implemented with a cause-and-effect relationship. Campbell and Stanley (1963) claimed that, because of time, pretest-posttest designs perform better in studies concentrated on learning. Therefore, this study employed a pretest-posttest quantitative research design. The design was a Time 1 and Time 2 design using data representative of the beginning and end of each of 5 academic years, using a random sample of data from each year. This method allowed me to get a baseline to move forward in collecting data.

Population

The population of interest in this study was 4- to 5-year-old preschool students in Turkey. In 2017, preschool attendance comprised 23.3% of all children in the target age group (OECD, 2020). As revealed by the MoNE (2018/19) national education statistics report, the number of children aged from birth to 5 is around eight million, which suggested that children aged 4 to 5 might come up to two-fifth of that total about 3.2 million. The population of preschool attendees (23.3% of 3.2 million) totals approximately 750,000 children. In this study, I included data from results of about 128 individual child assessments.

In this study, both preschools teach in English to children of expatriate, native English speakers and to children of Turkish families. All the parents are highly educated and aware of the importance of ESL instruction for their children and the development of children’s interest and ability in STEM. Students attending these schools come from middle class or high-income families. The sample size totaled 128 students, from both preschools combined.

Sampling and Sampling Procedures

There were two sampling strategies used in this study. The first one was choosing the two preschools to represent control and experiment groups. Non-probability sampling method was used to choose these preschools. According to the MoNE (2018/19) national education statistics reports, there are a total of 6,577 public and private preschools in Turkey. The aim of pre-primary education is to prepare children physically, emotionally, and mentally for primary education in a safe environment (MoNE, 2018/19). Private preschools are free to decide on their curriculum as long as they prepare children aged between 0 to 6 for the primary education. I had access to four preschools that follow the EYFS curriculum and serve expatriate families in the city that is the location of this study. Among these four preschools, only one of them teaches Code Studio as a part of its curriculum. I chose the other preschool among the other three expatriate serving preschools by contacting the preschool directors personally, and I chose the center whose director volunteered first to be a part of this research.

I then used a random sampling strategy to select the participant data from each school to be used in this study. The class sizes were not equal in each school; therefore a random sampling procedure was used to collect data from an equal number of children from each preschool archive. All students whose mathematics score data were included in the archives were included as part of the random sampling procedure; I excluded only students for whom mathematics score data were unavailable. According to application of GPower 3.1 (Faul et al., 2007), total sample size is calculated as 128 delivers an 0.05

alpha error probability. I collected archived data for 13 randomly selected students in each of the two schools for each year over the last 5 years.

Procedures for Recruitment, Participation, and Data Collection

In this research, I collected secondary data in the form of 13 preschool student mathematics scores from the archives of two preschools for each of 5 consecutive academic years, for a total of 128 data points. Upon receiving approval from the Walden University Institutional Review Board (IRB), I contacted the preschool directors and explained the study to them, along with the possible benefits of participating in the study. I explained to each director that student identifiers would not be included in the study, nor would the names of the centers themselves. I provided each director with a Letter of Cooperation for their signature. Upon receipt of written cooperation, I collected student report card data for mathematics skill from 13 randomly selected students for each of 5 years from each of the two schools. Student names were selected at random by applying a random number generator to the enrollment lists for 4- and 5-year-old children and identifying 13 students per year per center. This means that the 13 students per year were not necessarily the same students each year, so that data from more than 13 students per center composed the data.

Instrumentation and Operationalization of Constructs

The dependent variable, preschool students' mathematics ability, will be assessed at the end of two twice-yearly academic terms by teachers using oral assessments published by the EYFS. EYFS assessments are intended to help stakeholders follow standards for the development of 0- to 5-year-old children (EYFS, n.d.). The EYFS assessments are appropriate for this study because they suggest that preschool students should be able to identify numbers, shapes, colors, and units of money, interpret simple graphs, follow patterns, count, and make comparisons (EYFS, 2017). EYFS oral assessments are mandatory for British private schools, nurseries, and childminding services but also are used by international schools that would like to benefit from the assessments (EYFS, 2017). Teachers collect data on students' knowledge mathematics skills at the end of each term, which is at the midpoint of the academic year and at its conclusion. Teachers at both target preschools administer the EYFS mathematics assessments twice-yearly, therefore reliability will be established between the control and experiment groups in the study.

The independent variable, Code Studio (2020), is a computer program intended to teach computer programming to young learners and help them create their digital games. Code.org is a non-profit organization that focuses on teaching computer programming to women and underrepresented minorities (Karsenti, 2019). The aim for the application's participants is to move a graphically represented bird up, down, right, left, and around obstacles by coding sentence commands to do so (Vance & Verschoor, 2017). Young learners combine blocks of code due to this graphical programming (Vance & Verschoor, 2017). Code Studio is also an adult-friendly program (Karsenti, 2019), so teachers and parents can easily open an account for each learner (Code Studio, 2020). Each child has their password to sign in to their page as a graphic designer, and thus teachers can monitor their learning pace (Code Studio, 2020). Parents can work with their children because users and observers do not need previous programming experience

(Code Studio, 2020). Children move to a new step in the Code Studio program when they achieve mastery of a command. Because coding supports skill development in mathematics concepts such as number, spatial relations, geometry, and problem-solving, the use of this tool serves as the independent variable in this study of the effect of coding instruction on preschool children's mathematics achievement.

Data Analysis Plan

The research question that guides this study asks about the effect of computer coding classes on the mathematics scores of preschool students. SPSS software will be used to conduct the statistical evaluations. ANCOVA test will be used to determine differences in the change in classroom mathematics scores of preschool students (dependent variable) at the beginning and the end of the school year, after mathematics instruction (independent variable) where that instruction included or did not include computer coding instruction.

Threats to Validity

According to Campbell and Stanley (1963), internal and external validity are essential tools to tell if research is meaningful. In this research, the effects of maturation of the children during the first and second assessments can be an internal validity issue (Campbell & Stanley, 1963). All teachers will assess the mathematics scores of children following the requirements of the EYFS program, which supports internal validity (Campbell & Stanley, 1963). Possible staff changes among teachers who assess students might be an internal validity threat in this research. Students may become accustomed to the questions required by the national curriculum when they are assessed a second time, which can be another internal validity issue (Campbell & Stanley, 1963). These threats will be taken into consideration during data collection.

External validity affects the generalization of the results of a study (Campbell & Stanley, 1963). In this study, the external validity is enabled by choosing two preschools following the widely-used EYFS curriculum; however, because the schools are in Turkey, the findings of this research may not be generalized to other countries. Ethical Procedures

Following approval of my study by the Walden University IRB, I will contact the chosen preschool directors and explain the research and possible social change benefits of the research findings and obtain their written consent to access anonymized student mathematics assessment data. As secondary data are collected from both preschools' archives by administrators at each preschool, student names, gender, ethnicity, cultural, economic, and social backgrounds will not be included in the data shared with me. I will keep school directors' consent forms and anonymous student reports cards safe in a locker during the assessment process. Data should be kept safe for 3 years after the publication of the research study (Princeton University, 2021). I will contact the directors to get their approval on keeping the data for further need. All the paper files will be destroyed by a shredder and electronic files will be deleted from the computers, memory drives, and laptops.

Summary

I will use a quantitative pretest posttest quasi-experimental design for the comparison of mathematics achievement in two Turkish preschools that differ in their use of coding classes as a support to mathematics learning. I will collect secondary data from the archives of two preschools, one of which uses Code Studio to teach computer coding and the other does not teach computer coding. I will use random sampling to form a sample size of 128 data points. I will analyze data using ANCOVA. In Chapter 4, I will present the data and my analysis to determine the effect to computer coding classes on preschool mathematics scores.

Chapter 4: Results

The purpose of this quantitative study using a pretest posttest quasi-experimental control group design was to evaluate the effects of coding classes on the classroom mathematics scores of preschool students. One research question guided this research: Is there a statistically significant difference in mathematics growth over 1 academic year in preschool students who were taught computer coding compared to students who were not taught computer coding? The hypotheses were as below:

H_o: $\mu 1 = \mu 2$ There are no statistically significant differences in mathematics growth over 1 academic year in preschool students who were taught computer coding and students who were not taught computer coding, while controlling for the pretest scores.

H_a: $\mu 1 \neq \mu 2$ There are statistically significant differences in mathematics growths over 1 academic year between preschool students who were taught computer coding and students who were not taught computer coding, while controlling for the pretest scores.

I hypothesized that there was a statistically significant difference in mathematics growth over 1 academic year between preschool students who were taught computer coding and students who were not taught computer coding, while controlling for the pretest scores. In this chapter, I described the actual process of data collection, the results, and a summary.

Data Collection

After I received IRB approval (approval 06-09-20-0406264), I contacted directors of the control and experimental group schools to secure signed consent for secondary data collection. The director of the experimental group preschool that teaches coding agreed to share her secondary data and provided written consent. However, the director of the control group preschool, who previously had verbally agreed to participate in the study, had been replaced by a new director, who did not agree to participate in the study. Therefore, I consulted directors of other preschools in the target area that do not teach coding; one of them agreed to participate in the study and signed the written consent form. Walden's IRB approved this change of school. Both control and experiment group school directors then gave me secondary data of students' mathematics grades from the past 5 years (2015 to 2020).

Results

Both school directors gave me 64 randomly selected anonymous students' mathematics scores collected in two different academic terms: September and June. Secondary data indicated that teachers at both schools performed assessments in four topics: identification of basic shapes, of basic colors, and of numerals 1 to 50, and counting from 1 to 100. I transferred control and experiment group data to individual Excel spreadsheets. Then I transformed the rating labels indicated on the data to a 4-level Likert scale, transforming Excellent (E) to 4, Good Progress (G) to 3, Working on Skill (W) to 2, and Unsatisfactory (US) to 1, to permit data analysis. As shown in Table 1, the mathematics scores from both schools show that children were rated primarily at level 2 or 3 (of 4) in September, and in June were rated primarily at level 3 or 4. No children were rated at level 1 in June, although 12 children were rated at level 1 in September. The means and standard deviations for scores in September and June validated these observations. The mean scores increased from 2.49 in September to 3.29 in June, and the variability in scores reduced from September (.73) to June (.62). These findings indicate that when scores are combined for both schools, children increased their perceived understanding of the four assessed qualities over the course of the school year. See Table 1.

Table 1

Mathematics Scores Both Schools at Start and End of School Year

	September					June				
Score	*N*	Weighted score	*M*	*SD*	% of total	*N*	Weighted score	*M*	*SD*	% of total
1	12	12	2.49	.73	9.4	0	0	3.29	.62	0
2	47	94			36.7	11	22			8.6
3	63	189			49.2	69	207			53.9
4	6	24			4.7	48	192			37.5

The next question to pursue was if this progress in mathematics ability is found equally in each of the two schools. To determine this, I conducted an ANCOVA test.

Field (2013) suggested that assumption tests should be conducted before performing a statistical test. To perform an ANCOVA test for this pretest posttest quasi-experimental quantitative study, the first assumption to test was the similarity of the pretest grades between the control and the experiment schools. The second assumption was the homogeneity of regression that determine the linearity of the dependent variable across treatments. The third assumption was the homogeneity of the variance to determine the variance between control and experiment groups. The fourth assumption was to test the normality of each group over the dependent variable.

An ANOVA was run to compare pretest and posttest within group scores of the control and the experimental groups. There was no statistically significant difference at the .95 threshold of pretest and posttest scores of the control and experiment groups. Therefore, the first assumption was met. This suggests that any significant difference pretest and posttest scores between the groups might be attributable to the treatment of coding instruction.

A customized ANCOVA model was used to test the homogeneity of regression to help determine the relation between the dependent variable (June mathematics scores) and the covariate (September mathematics scores) on the independent variable (coding classes). When I tested between-subject effects, the significance value of the covariate by dependent variable interaction (group*sept) as shown in Table 2, there was a non-significant relationship between June mathematics scores and coding classes (see Field, 2013). Therefore, homogeneity of regression condition was met, See Table 2.

Table 2

ANCOVA Results for the Experimental Group Posttest: Tests of Between-Subjects Effects

Dependent variable: June

Source	Type III Sum of Squares	*df*	Mean square	F	Sig.	Partial Eta Squared
Corrected model	25.317[a]	3	8.439	45.523	.000	.524
Intercept	33.247	1	33.247	179.343	.000	.591
Group	.757	1	.757	4.085	.045	.032
Sept	22.940	1	.566	3.051	.083	.024
Group * Sept	.566	1	.566	3.051	.083	.024
Error	22.987	124	.185			
Total	1433.000	128				
Corrected total	48.305	127				

[a] R Squared = .524 (Adjusted R Squared = .513)

According to Field (2013), Levene's analysis helps to test the equality of variances across dependent variables. The output shown in Table 3 determined F (1,126) = 0.27 (p = 0.6), which was above the accepted threshold (p > 0.05). Therefore, the third assumption of variances was met, and equal variances were assumed, as illustrated in Table 3.

Table 3

Levene's Test of Equality of Error Variances[a]

Dependent variable: June

F	*df1*	*df2*	Sig.
.27	1	126	0.6

[a] Design: Intercept + Group + Sept + Group*Sept

I conducted a Shapiro-Wilk test to check the normal distribution. The results for both control and experiment groups indicate non- normality as p =0.00, which was below the given threshold. This suggests the ANCOVA test is robust and can override violations of normality (see Rheinheimer & Penfield, 2001). This is depicted in Table 4.

Table 4

Tests of Normality

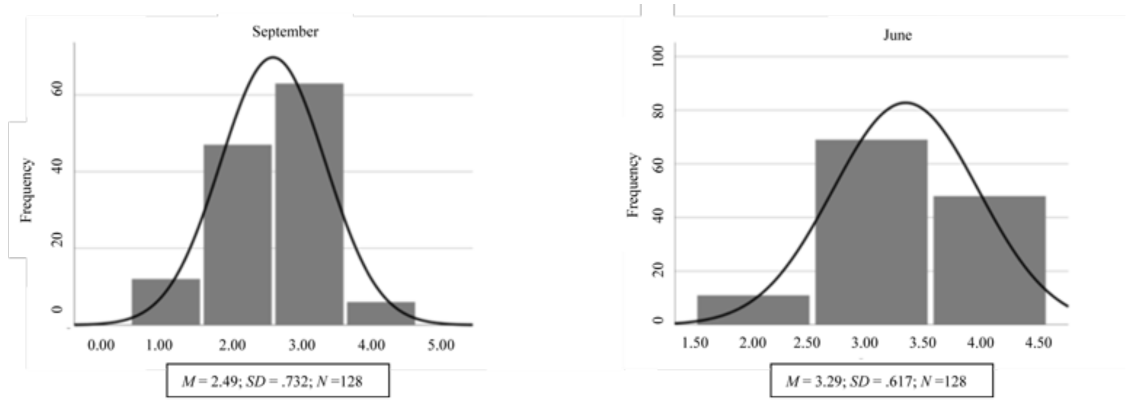
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	*df*	Sig.	Statistic	*df*	Sig.
Sept	.30	128	.00	.83	128	.00
June	.31	128	.00	.76	128	.00

[a] Lilliefors Significance Correction

According to Field (2013) for sample sizes larger than 100, significance levels calculated by the Shapiro-Wilk for normality can be discounted, if histograms, box-plots, and P-P plots indicate normality does not indicate violations. As shown in Figure 1, bell shapes indicate a normal distribution (Field, 2013).

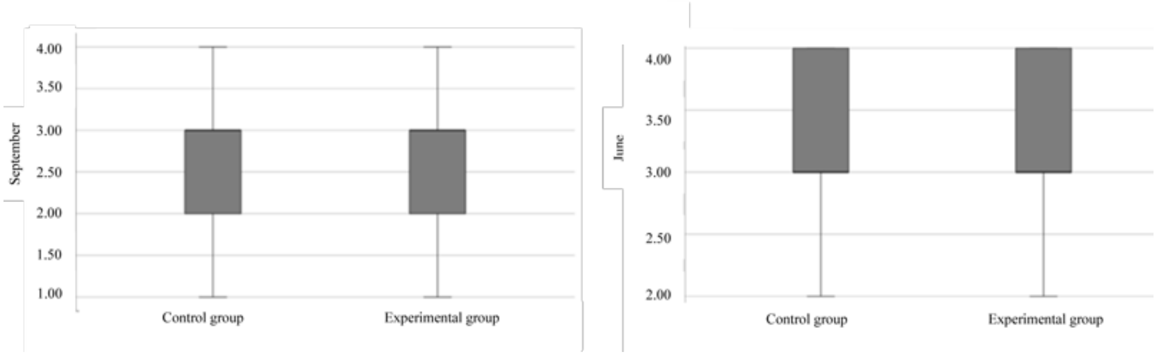
Figure 1

Histograms of Control and Experiment Groups Combined of Scores in September and June



As shown in Figure 2, no outliers were detected in the box plots of the September and June scores and normality was noticed (see Field, 2013). The blue boxes on the right graph indicates the mean scores in June, which is higher than the mean on the left which depicts September mean scores.

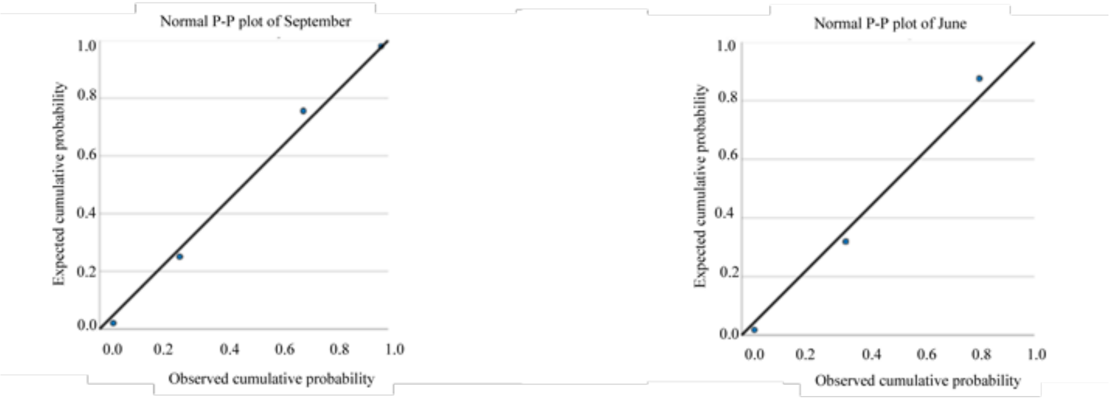
Figure 2.



Box plots of control and experiment groups scores from September and June

As shown in Figure 3, P-P plots indicate normality because data points were close to the ideal diagonal line (Field, 2013).

Figure 3.



P-P Plots of control and experiment group combined scores in September and June

According to Field (2013) bell shaped histograms, box plots, and P-P plot indicate normal distributions, therefore, I assume that there was no violation in the normality assumption.

Results for the Research Question

Depending on the non-violated assumptions, I performed an ANCOVA analysis. The results indicated that there was a statistically significant difference (p = 0.02) in mathematics growth over one academic year between preschool students who were taught computer coding and students who were not taught computer coding, while controlling for the pretest scores (See Table 5). The results of this ANCOVA analysis indicate that students achieved better mathematics scores when coding classes were taught with Code Studio.

Table 5

ANCOVA Results

Dependent variable: June4

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected model	5.72[a]	2	2.86	18.12	0.00
Intercept	37.29	1	37.29	236.43	0.00
Sep4	3.96	1	3.96	25.10	0.00
Group	.94	1	.94	5.99	0.02
Error	19.71	125	.16		
Total	1803.00	128			
Corrected total	25.43	127			

[a] R Squared = .23 (Adjusted R Squared = .21)

Summary

In this quantitative pretest posttest quasi-experimental control group design, I examined the effect of computer programming classes with Code Studio on the mathematics abilities of preschool children with an ANCOVA model using the SPSS statistical tool. The dependent variable, June mathematics scores of the control and experiment groups, was controlled for the covariate, September mathematics scores. I rejected the null hypothesis because there was a statistically significant difference in mathematics growth over one academic year between preschool students who were taught computer coding and students who were not taught computer coding, while controlling for the pretest scores. Children who were offered coding instruction scored significantly better in mathematics in June than did children who were not offered coding instruction. In Chapter 5, I presented an interpretation of this finding, limitations, recommendations for future research, and implications for practice. I also described implications for social change that could be derived from this study.

Chapter 5: Discussion, Recommendations, and Conclusions

The purpose of this quantitative study was to determine if there was a significant difference in the mathematics scores of 4- to 5-year-old students in two preschools, only one of which teaches coding classes as part of its curriculum. In this study, I used a pretest posttest quasi-experimental quantitative design to determine any difference between the mathematics scores of the control and the experiment groups. I used the SPSS software to conduct an ANCOVA test. A statistically significant difference was found that indicated a positive effect of coding classes on the mathematics scores of the preschool students. In this chapter, I discuss the implications of the findings, limitations of the study, recommendations for further research, recommendations for practice, implications for positive social change, and conclusions.

Interpretation of the Findings

Countries aim to raise critical thinkers with increased social abilities, good team workers to help their government take place in the global world. Therefore, international tests such as PISA and TIMSS are organized regularly to help policymakers evaluate their students' place globally (Anderson et al., 2007). Turkey participates in these global tests but achieves poor grades and low rankings. These scores indicated a need to identify the Turkish educational system's problems and take action to improve student learning, particularly in STEM subjects (Demir, 2018).

STEM education is based on student-centered learning activities that enable increased planning, critical thinking, problem-solving, and evaluation skills (Corlu & Aydin, 2016). Child-centered, interactive activities such as technology implementation enhance learning by extending the focus time, engagement, and attention of young learners (Kermani & Aldemir, 2015). The MoNE started the Movement to Increase Opportunities and Technology (FATIH) project to provide tablets to every student, equipping schools with internet and interactive whiteboards to make a technology reform in education (Aksit, 2007). The FATIH Project's main goal is to maintain equal access to educational resources and engage children with technology regardless of their social, economic, and cultural backgrounds to close the digital gap (YEGITEK, 2016b).

Early childhood education has not been considered a crucial step in improving global rankings in mathematics by the MoNE (Goksoy, 2017). The main aim of preschool mathematics education is to enhance children's cognitive skills and create positive attitudes towards mathematics, but preschool education is still not mandatory (MoNE, 2016). Although the early mathematics curriculum is primary, Gresham and Burleigh (2019) found that early childhood teachers experienced mathematics anxiety due to their lack of confidence in their knowledge. Early childhood teachers who have mathematics anxiety rely on traditional teaching methods, such as whole class teaching with the same textbook, flashcards, and worksheets, focusing on curriculum expectations rather than individual student learning (Gresham, 2018).

Kara and Cagiltay (2017) claimed that digital games encourage visual learning, enhance concentration ability, improve cognitive skills, and support children's self-confidence. Alkhawaldeh et al. (2017) found some teachers in Jordan preferred digital games over traditional teaching materials because digital games motivate, interact, and offer colorful graphics. Children performed better when taught with digital tools than they did when taught only by traditional methods. Teaching mathematics shifted from classical pattern memorization and repetitions to hands-on activities, data collections, and observations (Cheng, 2015).

According to Prensky (2001), teachers claimed that students might have a shorter attention span, but traditional teaching methods do not motivate students of the digital age anymore. Prensky (2001) further suggested that game-based learning might be a better teaching method to engage these digital natives, who communicate, play, and reach knowledge online. Siemens (2008) claimed that schools used to be formal instruction in the 19th and 20th century; however, students prefer to construct knowledge in their classes in the 21st century with the technology improvements.

In this study, computer programming was taught to an experimental group of 4- and 5-year-old students, and not taught to a matched control group. Coding is a tool to teach computational thinking (Sáez-López et al., 2016). Effective teachers can use coding to plan play-based digital learning lessons that are both child-centered and teacher-led so that children can be creative, plan, and take risks through digital activities (Bers, 2018). According to Campbell and Walsh (2017), coding should be taught in early childhood settings through hands-on, play-based activities that are engaging for young students.

Siemens's (2005) connectivism learning theory for the digital age formed the theoretical framework of this study. I evaluated the secondary data collected from control and experimental groups. Students in the experimental group were taught computer coding using the program Code Studio; students in the control group were not taught coding. All the students attending these preschools followed the same curriculum and administered the same assessments twice a year. In analyzing year-end mathematics scores, I controlled for differences in the September scores. I found a statistically significant difference between the mathematics scores of students in the control and experiment schools. Students, who were taught coding achieved significantly higher scores in June assessments than students who were not taught coding. Campbell and Walsh (2017) suggested that teachers support children's computational thinking when they embed coding activities into mathematics instruction. As Siemens (2008) suggested, children like those whose mathematics scores were represented in this study can benefit when teachers engage young learners' digital fondness and use coding classes to support their mathematics lessons.

Limitations of the Study

The sample for this study was collected from two preschools that serve children of highly educated parents in a specific city in Turkey. Although I assumed the two schools served a similar population and used the same general curriculum, a possible limitation of this study results from selection bias (Campbell and Stanley, 1963). The directors who agreed to supply secondary data may differ in specific ways from directors who did not (indeed, one director reversed the participation decision made by their predecessor) and the children that each participating center enrolls may differ in unknown ways. The fact that one center had offered coding instruction for at least 5 years prior to the commencement of my study suggests that parents of children enrolled in the experimental group center may have selected it because of a preference for coding instruction. Such parents and their children may differ from parents and children at the control group center in ways that affected the validity of my results. It is possible that the secondary data I collected may not offer an accurate picture of the effects of the coding classes on the mathematics scores.

Recommendations

Results of this study indicated that computer coding classes with Code Studio had a positive effect on young learners' mathematics scores. I recommend replication of this study with more than one center represented in the experimental and control groups, to reduce the effect of selection bias. To further explore the influence of selection bias on my results, a future study might assign children enrolled in the same school to extracurricular enrichment in which one group participates in computer coding and the second group participates in a contrasting topic of instruction, like drawing.

Additional research might include data collected from preschool students whose parents are not highly educated but are typical of Turkish students generally. I also recommend additional studies to determine the effect of coding instruction in preschool on mathematics success in elementary school, or on the effects of coding on young learners' language abilities and other learning in other STEM topics, such as scientific thinking or creative engineering. Longitudinal research might determine any positive effect of preschool coding on students' performance on global tests such as PISA and TIMSS, and even on their choice of college major and employment.

Further research might focus on the effects of coding lessons to overcome early childhood teachers' fear of mathematics lessons due to their lack of confidence in their mathematics knowledge, an issue suggested by Novak and Tassell (2017). In addition, research might compare the effectiveness of various coding programs, including Code Studio and Scratch, Jr., in supporting children’s mathematics skill development or in supporting teachers’ use of coding as an element of the preschool curriculum.

Implications

Coding is the new literacy for young learners in the twenty-first century. One implication of this study is that coding classes should be incorporated in early childhood education curricula, including in the EYFS curriculum. Another implication is the need that may exist for teacher training in using coding programs like Code Studio, and for computer equipment and technical support for preschools and childcare centers. Because the results of this study suggest that significant mathematics gains can be made by preschool-age children, an implication of this study is that preschool attendance required as part of the educational plan for all children; doing so may increase students’ scores later tests like PISA and TIMSS. To that end, I plan to share the results of my study with the MoNE. In addition, I will create and present a workshop for early childhood practitioners on the importance of computer coding classes in the early years. Positive social change will result from this study if coding instruction is incorporated more widely for preschool children, and children become more successful in mathematics.

Conclusion

The purpose of this quantitative pretest posttest quasi-experimental study was to evaluate the effect of coding classes on the classroom mathematics scores of preschool students. While controlling for start-of-year test scores, I conducted an ANCOVA and found a statistically significant positive outcome in end-of-year mathematics scores for preschool children who were taught computer coding using Code Studio. This finding was consistent over the 5 years of data, which I collected from two matched preschools enrolling native English-speaking children of highly educated expatriate parents and children of Turkish families. This finding suggests that learning to code at an early age increases students' skills in mathematics as measured on preschool assessments. Because early success in mathematics may lead to future success, early coding classes may have a positive effect on children's mathematics abilities in elementary school and may even result in improvements on global assessments like PISA or TIMSS among high school students. Increased mathematics achievement that might result from early coding instruction represents a positive social change that may be realized when coding instruction is adopted widely in preschool and childcare settings.

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