Northwestern College, Iowa

NWCommons

Master's Theses & Capstone Projects

Education

Fall 2022

Unplugged Learning in the Kindergarten Computer Science Classroom

Ashley Robinson

Follow this and additional works at: https://nwcommons.nwciowa.edu/education_masters

 Part of the Early Childhood Education Commons

Unplugged Learning in the Kindergarten Computer Science Classroom

Ashley Robinson

Northwestern College

An Action Research Project Presented

In Partial Fulfilment of the Requirements

For the Degree of Master of Education

December 2022

Dr. Angila Moffitt

Table of Contents

Abstract

The purpose of this action research study was to determine the impact of teaching computer science to kindergarten using only unplugged learning rather than plugged or a mixture of plugged and unplugged learning on engagement. Participants included 71 kindergarten and transitional kindergarten students in a public school in rural central Iowa. Data was collected through behavior and off-task reminder tallies, as well as assessment data over nine classes equal to a trimester's number of computer science classes. Students were taught using either strictly unplugged methods using games, books, manipulatives, and movement or a plugged/online curriculum using online puzzles and videos, including a couple of unplugged lessons. The study found that unplugged learning positively impacted behavior and off-task behavior. No statistical difference was shown in academic achievement; however, it is noted that more topics were covered in the unplugged group than that of the plugged group over the same amount of time. Overall, unplugged learning in kindergarten computer science class positively impacts engagement. The researcher recommends further studies extending the entire year of kindergarten, further studies extending the research through first grade should be considered as well.

Keywords: unplugged learning, plugged learning, kindergarten computer science, programming, coding, Code.org, ScratchJr

Unplugged Learning in the Kindergarten Computer Science Classroom

As new computer science (CS) standards are rolling out in Iowa schools, teachers are searching for resources and flocking to online activities and curriculums such as Kodable (Kodable for Schools and Districts, n.d.), Scratch (Scratch - Educators, n.d.), ScratchJr (ScratchJr - Teach, n.d.), and Code.org (Computer Science Fundamentals, n.d.). Though these resources are bountiful with benefits including accessibility, ease of use, interactive game-style lessons, and in many instances, low cost or free, most are primarily online, requiring more screen-time for students in an already digitally filled day. In today's America, screen-time quickly surpasses the recommended two hours of screen-time per day (Henderson et al., 2016 as cited in Lassak, 2018). With young children, recommendations of one hour of screen-time (Kerai et al., 2022) are overshadowed by digital learning throughout core subjects leading to "vulnerability in physical, social, emotional, and cognitive developmental health domains" (Kerai et al., 2022, p.7) as well as heightened behavior issues including those related to ADHD (Lassak, 2018).

With classrooms already filled with digital learning and studies showing the negative effects of screen-time, unplugged options are being considered. Similar to play-based learning, which has demonstrated holistic development (Lunga et al., 2022), unplugged learning with manipulatives in early-childhood classrooms has been found effective and motivating (Mutoharoh et al., 2021). With the awareness of the impacts of both play-based learning and screen-time among young children as well as the success of unplugged CS learning activities throughout higher grade levels, a need arises for such studies among kindergarten students before relying on predominately screen-based CS learning.

The purpose of this action research study is to determine the impact of teaching computer science to kindergarten using only unplugged learning rather than plugged or a mixture of

plugged and unplugged learning. The findings of this study will provide guidance for CS teachers as they prepare curriculum for kindergarten students, informing them of the value and benefits of an unplugged, play-based CS curriculum at the kindergarten level. With the implementation of new CS standards and guidelines, experts in education have been researching and exploring methods of teaching CS and their benefits; however, no studies have focused solely on unplugged, play-based learning in kindergarten and the impacts on not only achievement in CS but behavior as well. This research meets that criteria, focusing on a manipulative, active, play-based unplugged learning and both the achievement and behavioral results.

Research for this paper was drawn from the ERIC (Education Resources Information Center) database, the WorldCat discovery tool through DeWitt Library, and Google Scholar. All articles considered have been published in peer-reviewed journals within the last 10 years, including the years 2012-2022. Articles reviewed included studies of plugged and unplugged learning, play-based learning in early childhood, movement integration, student behavior, and the effects of screen-time. Of these articles, 22 were selected as sources relevant to the current study, providing background and identifying existing gaps related to kindergarten CS teaching and learning methods.

Review of the Literature

This literature review covers four areas of study pertaining to this action research. They first include the detrimental effects of one+ hour of screen-time on behavior; followed by the positive effects and struggles of both play-based learning as well as movement in the classroom. The final two areas relate solely to computer science learning, including research on plugged

learning options, focusing mainly on ScratchJr and Scratch programming, and culminating with the positives and negatives of unplugged learning approaches.

Screen-Time and Behavior

Multiple questionnaires have shown the ill-effects of greater than one to two hours of screen-time usage has on the behavior of young children. In Tamana et al.'s (2019) CHILD birth cohort study, parents of 3,455 five-year-old children completed a Child Behavior Checklist that included reporting their child's screen-time usage at ages three and five. Data was examined through the linear associations between screen-time and behavior, demonstrating a relationship between screen-time and inattention and behavioral problems. Results showed that screen-times greater than two hours were linked to an increased risk of inattention problems. These findings support similar research by McArthur et al. (2021), in which 1,994 mothers completed two questionnaires detailing screen-time at 4, 12, 24, and 36 months of age. The research team analyzed screen-time and relative "at-risk" scores. Whereas Tamana et al. (2019) found more than two hours of screen-time to negatively impact behavior, McArthur et al. (2021) found more than one hour of screen-time increased at-risk delays in achievement of developmental milestones, delays in language acquisition, and behavioral regulation. Whereas the allotted times may differ by an hour both studies demonstrate the negative effects on behavior in children ages five and younger, as well as achievement problems associated with screen-time usage.

Regardless of its use, either educational or entertainment, screen-time has been shown to, not only negatively impact behavior, but cause developmental vulnerability including school readiness. Parents of students entering kindergarten completed the Childhood Experiences Questionnaire; reporting on screen-time, health behaviors, demographics, and family income. The Early Development Instrument was used to measure the developmental vulnerability

compared to developmental health in the areas of physical, social, emotional, language and cognition, and communication skills (Kerai et al., 2021). Though there can be an educational benefit for screen-time (Radesky et al., 2015 as cited by Kerai et al., 2021), the results of this study show that children with more than one hour of daily screen-time are developmentally vulnerable in each of the five areas measured. Kerai et al. (2021) indicates that high levels of screen-time potentially negatively affect school readiness and developmental health as it displaces "free play-based and leisure activities that enhance cognitive and social-emotional skills that are key in promoting Kindergarten readiness" (Kerai et al., 2021, p.7). While there may be educational benefits from learning through screen-time, the negative impacts of more than one hour of screen-time per day appears to exceed the benefits in early childhood.

While early childhood studies more frequently agree on the relationship between one+ hour of daily screen-time and developmental vulnerabilities, Lassak's (2018) literature review of both children and adolescents highlights the detrimental effect of two or more hours of screen-time on a child's health, including sleep, the cardiovascular system, obesity, stress regulation, vision, depression and suicidal behavior, addictive screen-time behavior, predictive behavior, radiation, and ADHD. Lassak's (2018) case study, focusing on a decrease in screen-time, centered around a nine-year-old male who devoted time to digital media with no interest in after-school activities and was also underweight from a Ritalin prescription. Ritalin was prescribed due to exhibiting restlessness, hyperactivity, being easily distracted, having difficulties listening and following instructions, playing quietly, regularly disturbing his class, and behaving aggressively. Regardless of the Ritalin the behaviors increased. A screen-time reduction plan, that encouraged slow paced content, prohibited any screen-time one hour before sleep, and reduced overall screen-time, was implemented. Within the first two to four weeks of

implementation, the child h ad shown significant improvement; after 11 weeks the improvements were vast enough that the ADHD diagnosis was no longer relevant. This case study supports the negative effects of screen-time, evidenced by the fact that reducing screen-time can greatly decrease behavioral issues, including those of ADHD-related behavior.

Play-Based Learning and Movement

Whereas screen-time and learning through technology has quickly become popular, especially given the ease by which it is administered, other researchers recall the benefits and importance of play-based learning, a pedagogy formally established in the 1890s (Eberle, 2014; Ogunyemi & Ragpot, 2016 as cited by Lunga et al, 2022). Lunga et al.'s 2022 study focuses on play-based learning and holistic development among children; research included eight facilitators from three early childhood development centers. Using a qualitative, participatory action learning and action research method that engages observers, critical reflectors, and participants, Lunga et al. (2022) concluded that play-based pedagogy "is an indispensable pedagogy in the development of young children in all aspects of life, that is, moral, affectionate, physical, intellectual, emotional, social, and language development" (Lunga et al, 2022, p.7). In addition to these findings, Lunga et al. (2022) points out that learning through play is less stressful to the children than learning through the formal rigid methods used in older grades.

While play-based learning has shown to exhibit great benefits, not all areas of learning are always affected. Vogt et al.'s (2018) mixed method research compared 324 kindergarten students and 35 kindergarten teachers divided into two intervention groups, a play-based group and a training program group, as well as a control group. The semi-experimental educator-led training program, the guided play-based approach of card and board games, and the control groups were equally matched in curricular content; delivery of the content within the groups was

the only differing factor. Quantitative data was measured through pre- and post- one-to-one tests conducted by the researchers with each child. In addition, parents completed a socio-economic background and learning environment questionnaire. An ANOVA, or analysis of variance, was used to ascertain comparability between the groups. Qualitative data was collected from 30-40-minute phone interviews of the kindergarten teachers; transcripts were analyzed using qualitative content analysis. Vogt et al.'s (2018) findings showed "a significantly higher learning outcome from the group of play-based mathematics compared to the traditional kindergarten" (p. 598). Where typically the training program had shown significant learning outcomes, especially among those children with very low competency, no differences were found between the training program and play-based learning approaches, demonstrating the effectiveness of the play-based approach over the more traditional academic learning approach.

Through exploration and play, robotics can aid in the transformation of play-based learning. Research implementing robotics into a Montessori classroom setting, more similar to a play-based setting than a traditional academic setting looked at 19 first through third grade students and their teacher, Diana (Elkin et al., 2014). Preceding the implementation of robotics into the class, Diana participated in three days of professional development (PD) on the engineering and programming aspects of LEGO® WeDo™ robotics. Teachers who took part in the PD were required to implement robotics into their teaching and document their experiences throughout each step of curriculum implementation. Qualitative and quantitative data included Diana's experience documentation, two sets of surveys completed by Diana following implementation, as well as interviews and blogs. Results from Diana's six-day lesson, "The Playground: Facilitating a Multi-faceted Design Process through Robotics & Programming," demonstrated that though some technology is used, the addition of LEGO® WeDo™ robotics is

beneficial as long as Montessori philosophy is upheld and includes the use of materials that emulate traditional Montessori tangibles. Although students were documented as enjoying this curriculum addition and this approach to teaching an element of CS is very hands-on with minimal screen-time technology integration, Elkin et al. (2014) notes that no learning data was collected, making it impossible to measure students' academic benefits.

As play-based learning has exhibited its benefits, another includes student movement. Play-based learning incorporates and supports the allowance of movement in the classroom learning environment, the literature review of Webster et al. (2015) identifies the benefits of movement integration (MI) including improved physical, social-emotional, and mental health; increased academic standardized test scores; enjoyment and positivity; and perceived competence and effort in the classroom, including on-task behavior. Numerous studies highlighted by Webster et al. (2015) demonstrate the difficulty and lack of MI support due to school environment/culture and demands from academic content requirements. However, integrating movement into a play-based classroom structure would take little to no effort. Webster et al. (2015) concludes that though MI does not yet have supporting evidence for long-term benefits, the research does support benefits in the short term. Those benefits support not only the health of the student, but overall classroom environment with better student behavior and success.

Not only do students benefit from MI, but research shows they enjoy the addition to learning. McMullen et al.'s (2019) quantitative study of 135 primary school students in Ireland over the period of eight weeks introduced movement into classes. Following the conclusion of the eight weeks, students completed draw-and-write activities, showing themselves in the active lessons and writing about their feelings while participating. A total of 24 students were

additionally selected for interviews. Inductive analysis was used to determine specific themes within the groups including drawings, interviews, and field notes. Whereas Webster et al.'s (2015) study found health benefits from MI, McMullen et al.'s (2019) study omitted health-related measures and focused on the students engagement within the lessons, finding that students positively perceived movement integration, that lessons were fun and educational, and that MI provided additional exercise.

Lack of teacher experience and knowledge of play-based learning integration has shown to affect classroom implementation. A qualitative study of classroom observations and teacher interviews of three kindergarten classrooms concluded with three types of play-based learning approaches (Pyle & Bigelow, 2014). These three approaches consisted of the following: first, play as peripheral to learning where child-led play and teacher-constructed contexts of play provide a break from academic learning, allowing the teacher to pull students for small-directed instruction and assessment; second, play as a vehicle for social and emotional development, where child-led play provides opportunities for peer interactions and independently motivated tasks, allowing teachers to model and support social problem-solving strategies and join in children's play; third, play as a vehicle for academic learning, allowing child-led and teacher-modeled play to provide opportunities to internalize new academic concepts, the teacher taking the role of extending children's learning, introducing academic concepts to play, and facilitating discussions about contexts of play. Additional research conducted by Khalil et al. (2022) consisted of 26 teacher educators from four different universities in the Palestine. Through online surveys and semi-structured, open-ended interview questions, research found teachers are motivated to apply play-based pedagogy but are limited by lack of knowledge and skills. Though each of these studies exhibit areas of limitations, this could be attributed to lack of sufficient

knowledge in the area or simply differing opinions of areas of importance. Regardless of their lack of knowledge and skills, the studies each support the value of play-based learning.

Plugged Computer Science Learning

Moving from play-based learning to plugged learning on ScratchJr, young students are able to demonstrate their ability to understand coding concepts. Strawhacker & Bers (2018) research looked at 57 kindergarten through 2nd grade students in New England to find the cognitive domains (language, visual-spatial, etc.) young children leverage when learning programming for the first time. Students used ScratchJr programming for six weeks as the intervention. This group of students was chosen as they are a 1:1 iPad school and therefore had access to the necessary technology daily. The researchers used a mixed methods approach and collected data "in the form of children's responses on a post-intervention assessment of programming and comprehension and knowledge" (p.546). Qualitative data was taken from the numerically scored responses; qualitative data used trends in responses of incorrect answers. Findings showed that overall, students mastered foundational coding concepts, as well as some individual differences in performance and comprehension. In addition, data demonstrated the implications for the importance of introducing programming and coding at a very young age. Though the outcome of the intervention was successful, Strawhacker & Bers (2018) identify a further area of research to explore children's learning using a broad array of educational programming technologies including low-or no-tech activities, also known as unplugged learning.

As students are able to master foundational coding concepts, it is important to note if CS standards impact CS exposure. Continuing with research on ScratchJr, Bers & Sullivan (2019) focused on if exposure to CS standards delivered an increased exposure to coding for young

children. Using quantitative analysis, states with CS standards were compared to those without. Data collection from Google analytics on ScratchJr users, including trends by state, time of year, and types of in-app activities, was completed. Findings showed, as one would expect, that states with CS standards have more users on ScratchJr than states without. In addition, findings also showed a usage decrease on weekends and in summer months, indicating that ScratchJr sees more use at school than home. Further research could indicate that other programming applications could see more traffic; such research would not provide data for students using unplugged coding, rendering the data of young students' exposure to CS incomplete.

Other plugged learning options include Lightbox, though students using ScratchJr demonstrate more learning benefits. Rose et al. (2017) compared children's approaches of ScratchJr to those of Lightbox, another plugged programming learning option. Looking at 40 students between the ages of six and seven, the group was divided into two groups based on non-verbal reasoning tests and standardized school worksheets, after which students were paired. A 15-level, programming game was created, each to mimic either the style of ScratchJr or Lightbox. ScratchJr or Lightbox was used by each pair for 30 minutes while they faced away from each other. Data consisted of nonverbal reasoning scores, program manipulation, additions, moves and deletions of instructions per attempt, number of attempts needed by a participant to complete a level, highest level reached by each student, time taken by a student per attempt, and time taken by a student to complete a level. It was found that overall performance was similar between both programming options. Also found was that different aged children interacted differently with each interface. The ScratchJr-like interface had more program manipulation, higher ability children manipulated programs more, and there was no effect on Lightbox-like

players. Between these two plugged programming learning options, ScratchJr seems to have the greatest benefit.

ScratchJr's upper-level counterpart, while engaging, does not exhibit the same learning benefits as that of ScratchJr. Erümit (2019) researched Scratch looking at the effects of different teaching on the programming skills of 423 6th graders in three different schools. For this mixed methods approach, quantitative data was taken from the pre- and post-tests and qualitative data from semi-structured interviews with selected teachers and students. Findings showed that Scratch was easy and enjoyable but did not contribute meaningfully to problem-solving skills (p.1032). However, it did improve students' creativity by allowing them to exercise imaginations in electronic environment and foster positive attitudes towards tech and IT.

Using Scratch in combination with unplugged learning demonstrated no difference in programming concepts, but improvements were seen elsewhere. Hermans & Aivaloglou's (2017) research measured the effectiveness of plugged learning, beginning with unplugged learning then moving to plugged learning. This mixed methods research of 35 eight to twelve-year-old students in the Netherlands was broken into two groups; one began CS with Scratch programming, while the second group began with unplugged lessons for four weeks and switched to Scratch for the remaining four. At the beginning of the second week and the end of the eighth week, students completed a test for measurement and a questionnaire for self-efficacy. Scores were then averaged. Findings showed that after the eight weeks, no difference in understanding of programming concepts between the groups was found. However, the unplugged group showed improved self-efficacy beliefs. As this was a fairly small sample group, Hermans & Aivaloglou (2017) do recommend further research to replicate findings on a larger scale, as

well as to understand more deeply why the unplugged group saw such improved self-efficacy beliefs.

Unplugged Learning Approaches

Whereas Hermans & Aivaloglou's (2017) research found growth in self-efficacy with the unplugged group, further research found unplugged groups successful in other areas. Turan & Avdoğdu's (2020) coding research yielded higher scores for scientific process skills for students who used an almost entirely unplugged robotic coding program. Unlike Hermans & Aivaloglou (2017), this research did not look at the understanding of programming concepts between the students. Of the 30 kindergarten students who took part in this research, 15 were introduced to and used the robotic coding program. Throughout the eight weeks of the program all lessons, apart from one that used screen-time on Code.org, were unplugged. Mixed method data was compiled from personal information forms as well as a scale for preschool students' basic skills, measuring scientific process skills. Testing occurred both before and after the coding program.

As unplugged coding yields higher scientific process skills it paves the way for further exploration. Sullivan & Bers' (2017) research on unplugged CS learning using robotics in preschool consisted of 98 three- to six-year-old students in five different preschool centers in Singapore. Through seven weeks of lessons, quantitative data based on students' programming assessments and frequency of behaviors was collected, as well as qualitative data based on teacher interviews and journals. Though the need for much further research was identified, including comparing learning outcomes across digital tools and cross-cultural comparison studies, their findings showed that beginning in preschool, children can use unplugged technologies, like robotics, to learn fundamental engineering and programming skills that will set the stage for more complex projects and exploration in later schooling years.

Continuing with unplugged learning, it is important to note the ease and effectiveness of teaching CS in a cross-curricular setting, as demonstrated by Merino-Armero et al. (2022). Students from three sixth-grade classes in Spain were split into two groups, experimental and control. Whereas the control group went on learning Social Sciences as normal, the experimental group used some unplugged computational thinking activities in place of some typical activities. A quantitative post-test comparison of the two groups showed the cross-curricular approach to be effective for the development of the CS computational thinking skills. Whereas the research was successful in demonstrating the effectiveness of CS learning in a Social Sciences class, an increase sample size is recommended by Merino-Armero et al. (2022) for further study. Using other core classes for cross-curricular learning would also be beneficial research.

Unplugged learning is not only effective for learning cross-curricular topics, but it has been shown to increase proficiency in problem-solving as well. Mutoharoh et al.'s (2021) research demonstrates that unplugged learning is an effective tool to increase proficiency in problem-solving skills. A mixed-method action research approach looked at 20 kindergarten students. Qualitative data was obtained from observation and video documentation of children's unplugged play activities as well as interview results. Quantitative data was obtained from the calculation of the percentage increase in achievement in the development of problem-solving abilities before and after participating in unplugged activities. Not only did the findings show an increased proficiency in problem-solving skills, but they support learning through play as a way to stimulate initial problem-solving abilities and relate problem solving to the real world.

Though research has shown many benefits to unplugged learning, it also has disadvantages. Looking at the effectiveness of unplugged teaching pedagogy and the drawbacks, Busuttil & Formosa (2020) looked at 25 students ages 13-14 in Europe. Data for this qualitative

research was collected through observations, audio-recorded and transcribed discussions, as well as a worksheet following each activity used to assess students' knowledge. Data was then analyzed through thematic analysis. Unlike with plugged teaching, Busuttil & Formosa (2020) did find unplugged lessons to require much more preparation time to both set up and dismantle, making some activities not possible for every teacher. In addition, space and time can be an issue. Though these are certainly disadvantages to unplugged teaching, Busuttil & Formosa (2020) did find that unplugged activities promoted teamwork and students found them fun and engaging, allowing the students to be better focused during each activity.

Additional advantages in unplugged learning are found through the use of programmable robots. Saxena et al. (2019) researched computational thinking activities for preschool students, including how they perform in the activities as well as how teachers perceive the activities. The Hong Kong study used three groups of preschools, consisting of three to four students each, as well as their teachers. A total of ten hours, broken into five two-hour lessons each week, as well as a two-hour training for the teachers, aided in this mixed method research. Data was collected from performance assessments, lesson observations, and teacher interviews. Findings showed that nearly all students were able to reach the level of complete achievement in assessments of pattern recognition and sequencing. Teachers reported positive sentiments about computational thinking activities, saying that unplugged activities can provide students with concrete experiences to cultivate computational thinking and that unplugged learning helped students apply computational thinking skills to plugged activities. Though Saxena et al.'s (2019) research states unplugged and plugged activities, the plugged consists of using only a Bee-Bot programmable robot, which uses buttons on top of the bot to control directions and rotations.

Since this does not include screen-time but rather physical interactions and movement, it is being grouped into unplugged learning.

Methods

Research Question and Variables

The purpose of this action research was to determine the relationship between CS unplugged teaching methods and its impact on student achievement and behavior in kindergarten. The following question was used to guide this research: do kindergarten students exhibit more engagement learning CS through unplugged or plugged lessons? Typically, kindergarten CS is taught using Code.org's (2022) Computer Science Fundamentals Course, a curriculum using mainly plugged learning through screen-time videos and games with a few unplugged hands-on and screen-time-free activities interspersed throughout. As students typically struggle with the plugged component, slowing achievement and triggering behavioral issues brought on by frustration, the researcher sought to discover if an unplugged learning curriculum positively impacts engagement. The independent variable in this action research is unplugged learning using movement, games, and daily interaction. The dependent variable is the students' engagement. Other variables impacting this research beyond human control include safety drills (fire, tornado, and intruder), field trips, student absences, severe behaviors requiring adult intervention, and late school starts.

Site

This action research project was conducted in a rural school of 422 students in grades PK-6th grade in Central Iowa. Each grade consists of two to three classes of 20-30 students each, including a Transitional Kindergarten (TK) class averaging 12 to 17 students each year. According to the Iowa Department of Education (2022), the student population consists of

predominantly Caucasian students (93.6%), 3.3% Hispanic, .47%, or 2 total Black students, and 2.6% multi-race students. Currently the male to female ratio is an even 50/50 mix throughout the school (Iowa Department of Education, 2022), though the ratios differ greatly throughout each grade level each year. In 2021 the student population consisted of 12.9% of students with disabilities requiring the use of IEPs, and 34.8% of students qualified for free and reduced lunch (Iowa Department of Education, 2021).

Each grade attends one special class (art, music, physical education, and computer science) on an alternating schedule. Traditionally, art and CS are half-time specials alternating on the cycle, limiting contact to once every six school days for each of the two subjects. To maintain continuity and support learning, for each of the subjects the schedule has recently been changed to allow students the number of art classes needed to complete an art project or unit followed by the same number of CS classes to provide an equality among the subjects for a total of 28 classes of each subject per year. Each class ranges from 20-45 minutes depending on grade level and length of the school day. Typical days run classes from 8:10 to 3:25. Late start days have shorter classes to accommodate for the 9:40 late start schedule. Kindergarten classes are typically 20-30 minutes on this schedule.

Participants

Kindergarten is the focus of this action research. The kindergarten grade level consists of three classes; for this action research, TK was included in the research. The current TK class consists of 17 students: 12 female and 5 male students. The three kindergarten classes are more balanced between male and female students with 18 students in each of the three. TK's CS class is from 8:30 to 9:00 am on a typical school day, and Kindergarten's is from 10:25-10:55, immediately before lunch. Each of the three kindergarten classes has one to two students with

disabilities identified requiring 1:2 associate support during core academic learning. and an additional two students per class have an IEP for behavior or learning. TK has eight students receiving speech support, as well as one student with cerebral palsy limiting physical activity; this student has a 1:1 associate for support and behavior intervention. As CS is a specials class and not core academic learning, associates do not attend with students. The school year is divided into trimesters with grades due and conferences taking place a week prior to the official trimester ends.

By combining TK into this action research along with kindergarten the research will have larger groups to obtain data from. In addition, following TK, some parents choose for their children to jump to 1st grade rather than continuing through kindergarten; therefore, by keeping the curriculum the same for TK students, those who skip kindergarten and go on to first grade will not have great holes in their CS education. Those who do continue to kindergarten will have a review, with enrichment added as needed, giving them a strong CS foundation.

Intervention and Timeline

As the school year is broken down into trimesters this action research was conducted over the course of nine class periods, for a total of 27 weekdays, primarily throughout the first trimester with the same assessments being given to both the control group and the experimental group. The intervention and assessments of the unplugged curriculum was aligned to Code.org's Computer Science Fundamentals Course A curriculum (Code.org, 2022). For Code.org unplugged lessons that still require the use of computer technology, alternative unplugged lessons would be used to exclude that technology piece and focus instead on books, games, and movement to teach and learn the same information. In addition to assessment data to determine

achievement, behavior would be documented in the form of tally charts indicating the behavior for each student but not identifying the students.

Data Collection and Measurement Tool

The focus of this research was to determine engagement of unplugged learning versus plugged learning in a kindergarten CS class. Specifically, this researcher studied whether the independent variable of unplugged learning using movement, games, and interaction influenced the dependent variable of student engagement. Data was collected using mixed methods of quantitative and qualitative data collection.

Qualitative data collection consisted of behavior logs or tally sheets. The behavior logs used were identical to the standard kindergarten logs used routinely throughout each year. To indicate that a behavior reminder was needed, tallies were marked for more severe behaviors as well as for off-task behavior. As the observer, it is imperative to use disciplined subjectivity for the sake of validity. To aid in behavior log tracking, iPad recordings were used, watched following the class, and deleted immediately to maintain confidentiality.

Quantitative data consisted of achievement data based on assessments given at the completion of each unit. The same assessment was given to both the unplugged and plugged groups. Assessments were either unplugged assessments used throughout Code.org's Computer Science Fundamentals Course A curriculum (Code.org, 2022) or unplugged assessments created by the researcher used with both the control and testing groups to increase validity and reliability. Rather than solely worksheet or paper and pencil assessments most often used throughout Code.org's Computer Science Fundamentals Course A curriculum (Code.org, 2022), created assessments included the use of manipulatives and movement.

Following collection of both qualitative and quantitative data, a T-test was used to analyze the data and determine if any significant difference existed between the means of the plugged and unplugged groups. Hard copies of the data were kept in a locked office, then transferred to an Excel spreadsheet on the researcher's school-provided computer. Worksheet assessments were then returned to the students to take home. Behavior logs were shredded at the end of the trimester.

IRB Exemption

As this action research involved normal educational practices by comparing the methods of teaching through a plugged or unplugged curriculum on student engagement, an IRB exemption was granted and permission to conduct this research was approved by the Northwestern College Institutional Review Board. Respect for confidentiality of collected data was recognized and held in priority, as was informing students' parents of the study and providing an opportunity to deny consent. Every effort was made to ensure the participants safety and to accurately analyze and present the data collected.

Results

Data Analysis

To determine the difference in engagement of students between plugged and unplugged learning, qualitative data was recorded on tally sheets by the researcher during the course of the study to document behaviors and necessary off-task reminders during CS classes. The tallies were totaled by class, entered into an Excel spreadsheet, and plotted on a bar graph for viewing and quantitative analysis. Figure 1 shows the total number of tallies and/or reminders students received during each class, indicating that the plugged classes often received more tallies than the unplugged classes. Whereas the unplugged groups routinely received fewer than ten

reminders (most often less than five), only two plugged classes received fewer than five reminders. Further analysis was done to determine the cause. Figure 2 illustrates the days the plugged classes received fewer than five tallies. On these days the students were taking part in either unplugged learning following the Code.org curriculum or an unplugged assessment. Class three does indicate zero tallies for the Plugged K1 class; however, this data is due to students missing class for a field trip. Therefore, data was not collected that day.

Figure 1

Total Tallies/Off-Task Reminders Per Class

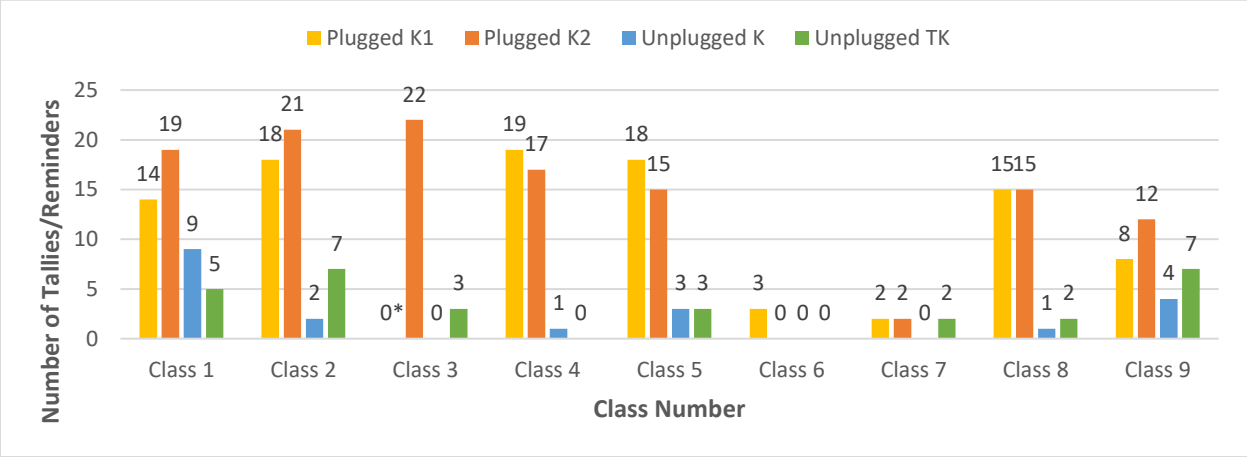


Figure 2

Plugged Group Class Breakdown

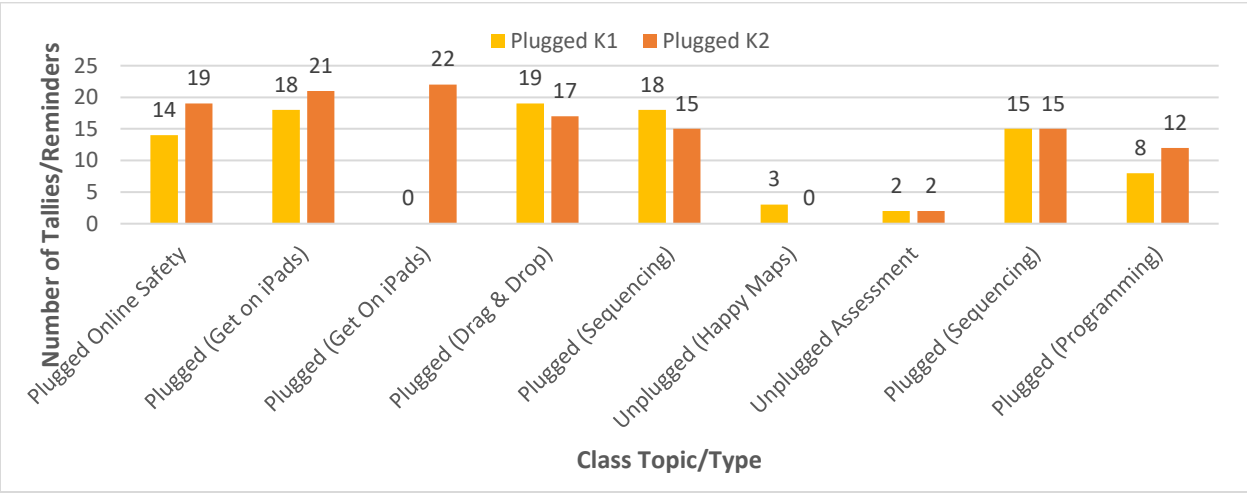
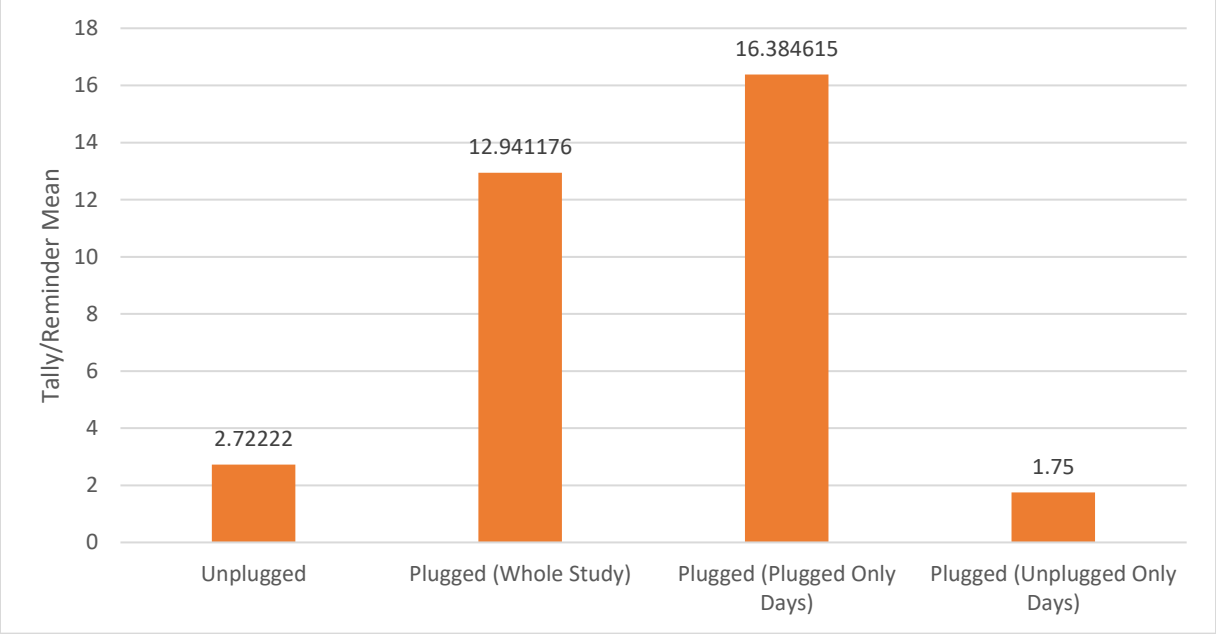


Figure 3 further depicts the analysis of behavior tallies and reminders by looking at the mean of not only each group, but also of the plugged group broken down into days of plugged lessons and unplugged lessons. Overall, the unplugged group had a low mean of 2.72 tallies and reminders, and the plugged group a higher mean of 12.94 tallies and reminders. Whereas the plugged group's mean is indeed greater, there is importance at looking at the breakdown of that group into only plugged classes (with a mean of 16.38 tallies and reminders) as compared to the only unplugged class days (with a mean of 1.75). In addition to the unplugged group's mean, these figures highlight the behavioral benefits of unplugged learning.

Figure 3

Tally/Off-Task Reminder Group Means and Breakdown



Quantitative data was collected via three assessments throughout the study. All three were looked at individually, and a t-test was used to analyze the data. The first assessment, focusing on online safety, ended the first class for each of the groups. Figure 4 depicts the scores of each student out of 11 points. (For this assessment six students were missing from the plugged

group; therefore, no data was collected for them.) The bottom row indicates the mean of each of the groups. Though one plugged group is higher than all other groups, overall, they are fairly equal. Results of a two-tail t-test support these findings, showing p=.29, indicating no statistically significant difference between the two groups.

Figure 4

Online Safety Individual Assessment Scores and Class Mean

	Plugged K1 (Class 1)	**Plugged K2 (Class 1)**	**Unplugged K1 (Class 1)**	**Unplugged TK (Class 1)**
	11	8	9	11
	10	8	9	10
	10	9	7	10
	11	9	8	9
	Absent	9	9	7
	8	9	5	9
	8	10	9	7
	9	9	8	7
	9	Absent	8	10
	7	8	9	7
	10	9	9	9
	7	8	10	5
	11	9	10	8
	10	Absent	8	8
	9	Absent	10	11

	Absent	Absent	8	10
	10	8	7	9
	9	5		
Mean	**9.3125**	**8.42857143**	**8.41176471**	**8.64705882**

The second of the assessments took place on different class days for each group due to the pacing of the curriculum. The unplugged groups completed the "Happy Maps" context-setting lesson and assessment during the second class. For the plugged groups, this same lesson and assessment didn't take place until the fifth or sixth class as the students first needed to learn not only how to use their iPads to get into their Code.org class, but also learn how to drag and drop the given blocks to properly link together for future algorithm creating. Like Figure 4, Figure 5 depicts the scores out of 12, as well as the mean of the scores of each of the groups. Unlike the previous assessment, where most of the means were fairly even, here one class from each of the groups are more even, with the unplugged groups both being slightly higher than the plugged counterpart. Again, supporting this analysis, a two-tailed t-test provided results of $p>.05$, indicating no statistically significant difference at $p=.28$.

Figure 5

Happy Maps Individual Assessment Scores and Class Mean

	Plugged K1 (Class 5)	**Plugged K2 (Class 6)**	**Unplugged K1 (Class 2)**	**Unplugged TK (Class 2)**
	10	8	9	Absent
	5	9	6	9
	5	7	12	9

	5	11	12	11
	6	10	7	Absent
	6	12	4	12
	6	7	6	7
	7	8	6	12
	12	11	6	12
	12	6	10	12
	6	12	Absent	12
	6	12	6	7
	12	11	7	9
	4	5	5	9
	10	Absent	11	7
	12	7	12	10
	5	9	Absent	7
	6	Absent		
Mean	**7.5**	**9.0625**	**7.93333333**	**9.66666667**

The final of the three assessments also took place during different classes due to pacing. The plugged groups were assessed during class seven, following the first of their sequencing puzzles on Code.org. For the unplugged groups, the assessment was given during class six, giving them time for three hands-on puzzles but to learn about debugging as well (debugging was not introduced to the plugged group in the Code.org curriculum until class eight). Debugging was not assessed in the final assessment; therefore, the unplugged group was not

given an advantage over the plugged group for this assessment—it was introduced naturally as mistakes were made as they worked on the puzzles and created algorithms. Figure 6 indicates student scores, out of seven, for the third assessment, "Writing Algorithms," as well as the means of each group. As with the first assessment, the means, though not identical, are more equal throughout. The completed two-tailed t-test results confirmed no statistical difference with p=.102.

Following analysis of each of the assessments individually, a two-tailed t-test was run on all assessment data between the two groups. As with the individual assessment t-tests, the t-test of the compiled data showed p=.23, p>.05, indicating no statistical difference between the plugged and unplugged groups. Though there is no statistical difference, this data shows that both the plugged and unplugged methods are equally effective in learning.

Figure 6

Writing Algorithms Individual Assessment Scores and Class Mean

	Plugged K1 (Class 7)	**Plugged K2 (Class 7)**	**Unplugged K1 (Class 6)**	**Unplugged TK (Class 6)**
	Absent	7	7	7
	7	5	7	7
	7	Absent	7	7
	7	Absent	7	7
	6	7	7	7
	7	7	7	7
	4.5	7	4	7
	3	6	4	7

	2	Absent	6	7
	5	5	5	7
	7	6	6	Absent
	7	7	4	4
	7	7	6	7
	7	5	7	7
	1	7	6	7
	7	Absent	7	7
	0	Absent	7	7
	7	Absent		
Mean	**5.38235294**	**6.33333333**	**6.11764706**	**6.8125**

Discussion

Summary of Major Findings

The findings of this study indicate that unplugged learning reduces the number of behavior tallies and off-task reminders. The data shows that though students in the unplugged group still received behavior tallies and off-task reminders, the number was significantly less than that of the plugged group, indicating that they were more engaged in the activities. Some of these tallies and reminders could possibly be attributed to those students who typically have associate support in the academic classroom; this consideration would benefit from further research. Looking further into the tallies and reminders of the plugged group, breaking it down into the plugged and unplugged days, data yet again supports unplugged learning as those class periods that were unplugged received significantly fewer tallies and reminders than those where

technology was used. Again, some of the tallies and reminders in the plugged group could be attributed to lack of associate support in the specials class; however, the greatest struggles seemed to take place when technology didn't work properly, the students went somewhere they shouldn't have been on the iPads, or when the iPads didn't respond as quickly as they wanted. These findings support research summarized in the literature review, including Tamana et al.'s (2019) study linking screen-time with inattention and behavior problems. Despite some tallies and reminders being required during unplugged classes, the researcher believes that the overall behavior and reminder data indicates unplugged learning is best suited for kindergarten aged students.

Though assessment data showed no significant difference in learning methods when it came to academic achievement, it is important to keep in mind the different timings of the assessments: the unplugged group's assessments were much earlier than those of the plugged group, indicating that they covered the material earlier and sometimes at a faster pace. In addition, the unplugged group was introduced to learning topics not yet covered in the plugged curriculum. Though these topics were not assessed, students seem to have an understanding of them, an understanding that will aid them in building their CS foundation.

Limitations of the Study

Throughout the research, despite best efforts, limitations existed. The first limitation was consistency of the class. As stated previously, the class was originally scheduled once every six weekdays. Though the researcher had unofficially altered the schedule to create more consistency and continuity, the class still meets only once every three weekdays and only for 20 to 30 minutes depending on the daily schedule. In addition, one class missed a day due to a field trip, and all days of plugged classes were cut four to five minutes short due to students needing

to return their iPads to the classroom before going to lunch. This lack of consistency in classes and shortening of classes could impact behavior and reminder results as well as work time benefiting assessment results. In addition to consistency, the research was limited to only nine days. Though equal to one trimester of classes, this is still not a great deal of research time. Though the research included four class groups, it was limited to the same rural school, with rather homogeneous demographics. These limitations could cause the research to not be relevant in larger, urban schools, or schools with more diverse demographics.

As the assessments used to gather data do not have published research to back up their validity or reliability, they are also a limitation. Though they were adapted from plugged assessments on Code.org, the accuracy on their ability to determine proficiency of student achievement could be questioned.

Future Research

Future research includes expanding the length of the study. Though not much more could be done about the frequency of the classes or the class length, further research could cover an entire year of the class, 27 classes total, and compare the results to this shorter, one-trimester study. In addition, further research could study the effect unplugged learning has on the following year, looking at how well the research subjects perform as first grade CS learners.

Another area future research could include is not only unplugged learning in kindergarten, but first grade as well. First graders are still very young, and as current studies show, young children should have less screen-time. Research could certainly have similar results as that of this study, benefiting the students with less screen-time. As Code.org offers a condensed, 14-lesson course covering the content from kindergarten and first grade, unplugged lessons could be used for both years with the chance for a quick plugged review at the end of

first grade or beginning of second grade or omitted altogether, beginning with the second grade plugged curriculum at the beginning of second grade and continuing the research to gauge the unplugged benefit through the lower elementary years. Additional research could include other schools with different demographics, larger class sizes, and more frequent class meetings.

Conclusion

The findings of this study suggest that unplugged learning may have a positive impact on kindergarten CS student engagement. As the data in Figure 3 shows, behavior tallies and off-task reminders are vastly reduced during unplugged lessons, including that of the students in the plugged learning group. Though there was a decrease in tallies and reminders for plugged groups towards the end of the research, as seen in Figure 1, there was still higher frequency compared to the unplugged groups. It is also unknown if this decreased fluctuation would have continued, worsened, or stayed the same. Given that most of the unplugged tallies and reminders were due to only a few students who typically receive additional support from associates, it is important to take this into consideration when examining the data.

Not only does unplugged learning positively affect the behavioral piece of engagement, but there is an effect on academic achievement as well. Though the assessment data shows no significant differences in learning, one must consider the pacing and additional content the unplugged group was learning as well. The unplugged group was learning more topics that naturally flowed into the lessons, not only exposing students to upcoming topics earlier than the plugged group but also going deeper into these topics. As previously stated, assessments were not given to include these additional topics; however, classroom observations indicate the students' understanding of them. As previous studies have shown the damaging effects of too much screen-time, it is critical to acknowledge the lack of screen-time for unplugged learning as

well as the benefits as students happily engage in books, games, personal interactions, and movement.

In comparison to using an online plugged curriculum, unplugged teaching does require a great deal more planning and preparation time, supporting Busuttil & Formosa's (2020) findings. Even so, given the results of this action research's findings, future kindergarten CS classes taught by the researcher will continue to use unplugged lessons, with future research looking at the benefits of unplugged learning in first grade as well and the impact on second grade plugged learning and overall elementary CS understanding.

References

Bers, M. U., & Sullivan, A. (2019). Computer science education in early childhood: The case of ScratchJr. *Journal of Information Technology Education: Innovations in Practice*, *18*, 113–138. https://doi.org/10.28945/4437

Busuttil, L., & Formosa, M. (2020, December 9). Teaching computing without computers: Unplugged computing as a pedagogical strategy. *Informatics in Education*, *19*(4), 569–587. https://doi.org/10.15388/infedu.2020.25

Computer Science Fundamentals. (n.d.). Code.org. Retrieved September 18, 2022, from https://code.org/educate/curriculum/csf

Course A (2022) - Code.org. (n.d.). Retrieved September 18, 2022, from https://studio.code.org/s/coursea-2022

Elkin, M., Sullivan, A., & Umashi Bers, M. (2014). Implementing a robotics curriculum in an early childhood Montessori classroom. *Journal of Information Technology Education: Innovations in Practice*, *13*, 153–169. https://doi.org/10.28945/2094

Erümit, A. K. (2019, September 13). Effects of different teaching approaches on programming skills. *Education and Information Technologies*, *25*(2), 1013–1037. https://doi.org/10.1007/s10639-019-10010-8

Hermans, F., & Aivaloglou, E. (2017, November 8). To Scratch or not to Scratch? *Proceedings of the 12th Workshop on Primary and Secondary Computing Education*. https://doi.org/10.1145/3137065.3137072

Iowa Department of Education. (2021). *Pleasantville Elementary*. Iowa.Gov. Retrieved July 30, 2022, from

https://www.iaschoolperformance.gov/ECP/StateDistrictSchool/SchoolSummary?k=12831&y=2021

Iowa Department of Education. (2022). *2021-2022 Iowa public school building PreK-12 enrollments by school.* Iowa.Gov. Retrieved July 29, 2022, from https://educateiowa.gov/documents/public-school-building-prek-12-enrollment-grade-race-and-gender/2021/12/2021-2022-iowa

Kerai, S., Almas, A., Guhn, M., Forer, B., & Oberle, E. (2022, February 15). Screen time and developmental health: Results from an early childhood study in Canada. *BMC Public Health*, *22*(1). https://doi.org/10.1186/s12889-022-12701-3

Khalil, N., Aljanazrah, A., Hamed, G., & Murtagh, E. (2022, January 29). Exploring teacher educators' perspectives of play-based learning: A mixed method approach. *Education Sciences*, *12*(2), 95. https://doi.org/10.3390/educsci12020095

Kodable for Schools and Districts. (n.d.). Programming for Kids | Kodable. Retrieved September 18, 2022, from https://www.kodable.com/schools-and-districts

Lissak, G. (2018, July). Adverse physiological and psychological effects of screen time on children and adolescents: Literature review and case study. *Environmental Research*, *164*, 149–157. https://doi.org/10.1016/j.envres.2018.01.015

Lunga, P., Esterhuizen, S., & Koen, M. (2022, June 1). Play-based pedagogy: An approach to advance young children's holistic development. *South African Journal of Childhood Education*, *12*(1). https://doi.org/10.4102/sajce.v12i1.1133

McArthur, B. A., Tough, S., & Madigan, S. (2021, May 19). Screen time and developmental and behavioral outcomes for preschool children. *Pediatric Research*, *91*(6), 1616–1621. https://doi.org/10.1038/s41390-021-01572-w

McMullen, J. M., MacPhail, A., & Dillon, M. (2019). “I want to do it all day!”—Students’ experiences of classroom movement integration. *International Journal of Educational Research*, *94*, 52–65. https://doi.org/10.1016/j.ijer.2018.11.014

Merino-Armero, J. M., González-Calero, J. A., Cózar-Gutiérrez, R., & del Olmo-Muñoz, J. (2022, January 28). Unplugged activities in cross-curricular teaching: Effect on sixth graders’ computational thinking and learning outcomes. *Multimodal Technologies and Interaction*, *6*(2), 13. https://doi.org/10.3390/mti6020013

Mutoharoh, Hufad, A., Faturrohman, M., & Rusdiyani, I. (2021, April 30). Unplugged coding activities for early childhood problem-solving skills. *JPUD - Jurnal Pendidikan Usia Dini*, *15*(1), 121–140. https://doi.org/10.21009/jpud.151.07

Pyle, A., & Bigelow, A. (2014, August 22). Play in kindergarten: An interview and observational study in three Canadian classrooms. *Early Childhood Education Journal*, *43*(5), 385–393. https://doi.org/10.1007/s10643-014-0666-1

Rose, S., Habgood, M. P. J., & Jay, T. (2017, August 1). An exploration of the role of visual programming tools in the development of young children’s computational thinking. *Electronic Journal of E-Learning*, *15*(4), 297-309. https://doi.org/10.34190/ejel.15.4.2368

Saxena, A., Lo, C. K., Hew, K. F., & Wong, G. K. W. (2019, August 22). Designing unplugged and plugged activities to cultivate computational thinking: An exploratory study in early childhood education. *The Asia-Pacific Education Researcher*, *29*(1), 55–66. https://doi.org/10.1007/s40299-019-00478-w

Scratch - Educators. (n.d.). Retrieved September 18, 2022, from https://scratch.mit.edu/educators

ScratchJr - Teach. (n.d.). Retrieved September 18, 2022, from https://www.scratchjr.org/teach

Strawhacker, A., & Bers, M. U. (2018, August 20). What they learn when they learn coding: Investigating cognitive domains and computer programming knowledge in young children. *Educational Technology Research and Development*, *67*(3), 541–575. https://doi.org/10.1007/s11423-018-9622-x

Sullivan, A., & Bers, M. U. (2017, January 23). Dancing robots: Integrating art, music, and robotics in Singapore's early childhood centers. *International Journal of Technology and Design Education*, *28*(2), 325–346. https://doi.org/10.1007/s10798-017-9397-0

Tamana, S. K., Ezeugwu, V., Chikuma, J., Lefebvre, D. L., Azad, M. B., Moraes, T. J., Subbarao, P., Becker, A. B., Turvey, S. E., Sears, M. R., Dick, B. D., Carson, V., Rasmussen, C., Pei, J., & Mandhane, P. J. (2019, April 17). Screen-time is associated with inattention problems in preschoolers: Results from the CHILD birth cohort study. *PLOS ONE*, *14*(4), e0213995. https://doi.org/10.1371/journal.pone.0213995

Turan, S., & Aydoğdu, F. (2020, April 11). Effect of coding and robotic education on pre-school children's skills of scientific process. *Education and Information Technologies*, *25*(5), 4353–4363. https://doi.org/10.1007/s10639-020-10178-4

Vogt, F., Hauser, B., Stebler, R., Rechsteiner, K., & Urech, C. (2018, June 21). Learning through play: Pedagogy and learning outcomes in early childhood mathematics. *European Early Childhood Education Research Journal*, *26*(4), 589–603. https://doi.org/10.1080/1350293x.2018.1487160

Webster, C. A., Russ, L., Vazou, S., Goh, T. L., & Erwin, H. (2015, April 21). Integrating movement in academic classrooms: Understanding, applying and advancing the knowledge base. *Obesity Reviews*, *16*(8), 691–701. https://doi.org/10.1111/obr.12285