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Using Online Interventions to Address Summer Learning Loss in Rising Sixth-Graders

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Abstract

Summer learning loss affects students to different degrees across curriculum areas. Traditional content review methods have often included workbooks or practice packets that lacked real-time feedback to the student. This study provided optional weekly online math and science review lessons to rising sixth-graders in two midwestern schools over the ten-week summer break. Students received both automated feedback from the online environment and teacher feedback in response to student questions or information students needed to acquire mastery. Students also had the opportunity to revise and edit their work. A test group, summer computer-based intervention group (SCBI), and a control group, completed a spring semester pre-assessment and a fall semester post-assessment to measure the change in math and science knowledge over the summer. The successful performance of the SCBI group on the post-assessment was statically significant when compared to the control group.

Keywords: summer learning loss, summer slide, summer set back, summer learning effect, summer intervention, online intervention.

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Chapter 1: Introduction

Each school year, many students return to school knowing less about content taught than when dismissed for summer break. Student achievement scores decline an average of one month due to the decline during summer break (Cooper et al., 2000). In a meta-analysis, Cooper et al. (2000) found that summer learning loss was most prevalent at higher grade levels, in mathematics (when compared to reading), and with historically disadvantaged student populations. Summer learning loss (SLL) also termed, summer learning effect, summer setback, summer brain drain, and more commonly termed, summer-slide all describe the decline or stalling of academic achievement between school years, typically between the spring and fall terms in the American school systems. To what extent does student-directed learning that incorporates technology intervention throughout the summer reduce SLL in rising sixth-graders in suburban midwestern schools?

Background

Summer Learning Loss is not a new phenomenon. To fully understand the problem, one must first understand that breaking up the school year to take summers out of school was not an agrarian model (von Hippel, 2019). In the early 1900’s New York City School administrators agreed upon a common calendar for schooling, reducing the attendance days from 248 to around 200. This plan allowed students to escape the non-air conditioned classrooms and travel with their families to the cooler countryside while the teachers prepared lessons and continued professional development. There is, at present, a variety of schedules across the United States. Some school districts are reducing the number of school days, moving start dates to after Labor Day (Erb, 2017), and twenty-five states have districts operating on a four-day schedule (Fischer, 2019).

Sarah Pitcock of the National Summer Learning Association identifies "more than 100 years of research on the academic setbacks related to students [varying lengths of summer break], and newer research on the employment and health implications of this disparity, it is clear that the summer slide is everyone's problem" (Pitcock, 2015). David Von Drehle, in a 2010 article in *Time,* points to the barriers of economic cost and culture of tradition. "Adding days and weeks to the academic calendar are costly, and families want their children to have the carefree summers they had." Seeking a way to add academic time with minimal cost while allowing student mobility to visit grandparents, travel with families, or even have extended trips and camps is a strong preference to costly summer school or extending the current school year.

Many schools review materials covered in the previous year for the first two months of school (Dunbar, 2018). This reteaching period immediately reduces the learning potential by 20% every school year. As a result, by the time students reach sixth grade, they have spent almost a full year reviewing material taught earlier in their academic life. This review can hold strong students back while others catch up. Dunbar states that some struggling students may take five months to catch up, reducing their learning potential by 50%. Summer interventions have the potential to mitigate not only summer learning loss but also reduce persistent achievement gaps (Kim & Quinn, 2013). Gains can be made reviewing content for 70 hours per summer or about 6.5 hours per week.

Recent investigations of Cooper et al. Beginning School Study found two errors in tracking the impact of how summer effects learning. The study using the California Achievement Test (CAT), concluded that reading and math gaps tripled over summer breaks, growing the achievement gap each year through 8th grade. The CAT used the Thurstone Scaling during the study, which showed learning loss over summer vacation. The CAT then switched to Item Response Scaling, showing some shrinkage in summer learning loss over summer vacation. This change in the statistical reporting of scores reveals errors of consistency within the study period. By changing the instrument during the process they are no longer comparing data with the same score reliability, it is no longer an apples to apples comparison. This study also includes the practice, which was standard at that time, of giving a fixed form test in the spring to students as they exit a grade and the fixed form test of the next grade to students when they arrive at school in the Fall. Von Hipple (2019) argues that comparing the results of these two different tests shows a larger learning gap due to the different questions on the fixed-form tests. In other words, when comparing test test data, it is important to have assessments that use the same language and ask the same questions. When there are differences in language or set up this can make it difficult to discern if the change in score is due to a lack of content knowledge or a lack of understanding of the question.

Paul von Hipples' search for recent patterns using the Early Childhood Longitudinal Study of more than 20,000 students and Measures of Academic Progress Tests (MAP) concluded two different results. The latest versions of the MAP tests are adaptive tests, which give students different questions based on the response to previous questions. These tests are more accurate but show some students lose knowledge, some students gain knowledge, and some students' knowledge level remains constant over the summer months. The Early Childhood Longitudinal Study shows students lose up to three months of progress in reading and math each year. Discarding the foundational Beginning School Study due to inconsistent questions and lack of conclusive results from the Early Childhood Longitudinal Study and MAP Tests, summer learning loss is still not fully understood. Von Hipple (2019) states, "The problem could be serious, or it could be trivial. Children might lose a third of a year's learning over summer vacation, or they might tread water. Achievement gaps might grow faster during summer vacations, or they might not." However, von Hipple (2019) continues, "nearly all children, no matter how advantaged, learn much more slowly during summer vacations than they do during the school years. That means that every summer offers children who are behind a chance to catch up. In other words, even if gaps do not grow much during summer vacations, summer vacations still offer a chance to shrink them."

Providing incentives and rewards is crucial to promote consistent effort (Fisher et al., 1981). For instance, framing non-fiction reading as homework rather than recreational is less likely to transfer as motivating and may be a disincentive (Anderson et al., 1988). Relating reading a book, website, or map to an upcoming trip makes the research interesting and builds connections, research, recall, and memory. Texting reminders of tips and strategies to use over the summer leverages parents as an intervention. Email newsletters are another method to remind families of how to make the most of learning technology over the summer. Students are already spending more time on electronic devices during summer break, so guiding screen time is essential (Kraft & Monti-Nussbaum, 2017).

Approximately 15,000 school districts in the United States are below the international average in total annual instructional time with a national average of 1,101 hours. However, instructional hours are higher in mathematics and science in American schools compared to other high achieving math and science countries. American schools have a shorter school year but spend more time on math and science ("A Nation at Risk," 1983). American summer breaks typically do not have support, remediation, or shadow education opportunities for students to maintain their academic skills (Wiseman & Baker, 2004). Summer remediation programs are not as prevalent in America (Yair, 2000) as compared to other nations that score higher on the Third International Mathematics and Science Study (Beaton et al., 1996). Summer breaks are typically shorter in other countries, and families have several options for school-like experiences for students to attend during extended breaks.

More time in school is not a solution, and breaking up the school year is not practical in the foreseeable future (Borman, 2000). Learning outside of the school day is becoming more structured and supplements formal school learning opportunities. Technology can be an equalizer and a low-cost alternative to enrolling in many summer programs. U.S. Policymakers should be looking at opportunities for accessing out-of-school instruction as other nations have done.

Statement of Problem

Summer learning loss is an ongoing challenge in education that impacts disadvantaged students greater than other students (Downey et al., 2004). Each school year, students work to regain what they have lost instead of building on previous knowledge, resulting in a gap in knowledge. This gap in knowledge compounds as students move up levels within the education system and impacts math and science to a greater degree than other areas. Many summer programs across the country work towards closing this achievement gap. Summer programs vary in focus and show different degrees of success. Overall, summer programs have minimal impact on changing this pattern of loss and review from the end of one school year to the beginning of the next (Cooper et al., 1996).

Theoretical or Conceptual Framework

With the majority of school districts functioning on an agrarian calendar, students are left with a summer break that can last ten to twelve weeks. This time out of school contributes to a loss of academic progress addressed at the beginning of the next school year. The faucet theory describes the school year as a period where learning is occurring because the “faucet” is running and summer as a period where learning is not occurring because the “faucet” is turned off

(Entwisle et al., 2014). This intervention keeps the “faucet” running for students during that summer period through an interactive web and real-world based model targeting science and math skills.

As part of this framework, students access the provided lessons in a manner that matches their prior knowledge and allows them to reinforce schema from the previous school year. This cognitive constructivist approach provides ongoing practice with concepts and positively reinforce students through feedback (Wadsworth, 1996).

In addition, Lave’s Situated Learning Theory connects the idea that learning is not prescribed but is a natural outcome of challenging experiences and embedded within an activity or context (Lave, 2016). Programs that focus on novel scenarios and project-based learning scenarios can provide students with summer experiences with an academic purpose without the over prescribed feeling of school. Constructing a rocket that can travel the farthest with limited materials or reporting temperature and observational data in order to create generalizations about your environment, to name two examples.

Purpose Statement

The objective of this study is to determine whether reducing or eliminating rising sixth-grade students’ summer learning loss of science and math content knowledge through an online intervention throughout the summer may provide more time for learning the following year. Data will measure to what extent student-directed learning that incorporates technology throughout the summer reduces SLL in rising sixth-graders in suburban midwestern schools.

Research Questions

1. What impact does an online intervention have on rising sixth-grade student retention and achievement in science and mathematics content?
2. To what degree does the number of lessons completed through the online intervention impact student retention and achievement in science and mathematics content?

Hypothesis

H_1 There is a significant difference between students who practiced math and science through the online intervention and those who did not practice math and science through the intervention.

H_{01} There is no significant difference between students who did not practice math and science through the online intervention and those who did practice math and science through the online interevention.

H_2 There is a significant difference between students who complete more lessons of the science and math online intervention than students who complete fewer lessons of the science and math online intervention.

H_{02} There is no significant difference between students who complete more lessons of the science and math online intervention than students who complete fewer lessons of the science and math online intervention.

Students that spend more time using the technology for review through the summer will not have higher achievement on the science and math content assessment in the fall.

Significance

There is data on summer school and reading interventions at home regarding SLL, but no examinations of at-home technology use as interventions over the summer. The timing of this study is significant because as technology access is becoming ubiquitous among upper elementary students, summer learning loss continues. Using technology as a platform to review materials during the summer will help students be more successful in entering the next grade. Students finding success in STEM courses are more likely to seek a STEM career (Wang, 2013) and find more success in school (Maltese et al., 2014).

The use of smartphones, tablets, laptops, and home computers continues to grow among students in this age group. In 2018, the National Center for Educational Statistics (2019) reported 89.9% of Missouri households have a computer or smartphone and 83.9% of households are connected to the internet. This data shows an increase of 1.5% of homes with a computer or smartphone and 4% increase of households connected to the internet in one year.

Definition of Terms

Automated feedback: Performance tasks and questions like Categorize, Essay, Matching, Multiple Choice, Multiple Selection, Numeric, Resequence, Short Answer, and True or False questions are scored by the software when an answer key is set up. Students receive instantaneous feedback including correct, incorrect, hints, and a prompt to try again and resubmit (Formative, 2019).

SCBI: Summer Computer-based Intervention group

Summer learning loss: Comparing children's gains in achievement over the summer, when they are out of school, with their gains when school is in session (Entwisle, 1992). Similar terms include summer learning effect, summer setback, summer brain drain, and summer slide.

Teacher feedback: teacher response to student work on lessons through a **web** browser or mobile device conveniently accessed anytime, anyplace (Formative, 2019).

Summary

Summer learning loss describes the decline or stalling of academic achievement between school years. There has been more than 100 years of research on the academic set back, so it is not a new phenomenon. Summer breaks are typically shorter in other countries, and those families have many options for school-like experiences during extended breaks. SLL impacts every student, SLL impacts disadvantaged students greater than other students. Schools address SLL with the loss and review model where the loss is accepted and the students review previous material at the start of the next school year. Entwisle's Faucet Theory describes the school year as a time when resources are available to students (faucet on) and summer when resources are not available to students (faucet off). Lave's Situated Learning Theory describes learning as a natural outcome of challenging experiences embedded within an activity. The study measures to what extend student-directed learning that incorporates technology throughout the summer reduced SLL in rising sixth-graders in suburban midwestern schools.

Research Questions

1. What impact does an online intervention have on rising sixth-grade student retention and achievement in science and mathematics content?
2. To what degree does the number of lessons completed through the online intervention impact student retention and achievement in science and mathematics content?

Chapter 2: Literature Review

Introduction

Many students return to school each Fall knowing less content than they did when dismissed for summer break (Cooper et al., 2000). On average, student achievement scores are one month lower due to the decline during summer vacation. In a meta-analysis, Cooper et al. (2000) found more summer learning loss at higher grade levels, more in mathematics than reading, and historically disadvantaged student populations are affected to the greatest extent. Summer learning loss, summer learning effect, summer setback, and more commonly termed, summer-slide all describe the decline or stalling of academic achievement between school years, typically between the spring and fall terms of the American school systems.

An Elton B. Stephens Co (EBSCO) host search produced 219 results for summer learning loss and 39 for summer learning effect search terms. An Eric database search yielded that 90 of the 219 search hits in EBSCOhost including 68 reports, 38 academic journals, 16 dissertations, and two books ranging in publication from 1966 to 2018. Fifty-five percent of these documents were published since 2008, reflecting a more significant interest in student achievement since the No Child Left Behind Act (NCLB) in 2001. NCLB refers to the reauthorization of the Elementary and Secondary Education Act of 1965, which required stronger accountability and measurement of annual yearly progress (AYP) in all state federally-funded schools and school districts (NCLB, 2002). This data also identifies the progress of students with low socioeconomic status (SES).

Summer learning loss as a continued phenomenon has been perpetuated throughout the years. With its greatest researched effect documented on reading. Whittingham (2015) noted that “loss of reading comprehension skills or reading achievement has been a well-known and well-documented phenomenon of public education for decades.” (p. 19). Donohue and Miller’s study went as far as to say:

> “as much as two-thirds of the differences among students in rates of participation in academic tracks in high school, dropping out of school, and completion of four years of college could be traced back to summer learning loss that occurred during elementary school.” (2008, p. 19)

Summer learning loss was documented as early as 1906 in the *American Teacher Magazine* when William White wrote the “neglect for three months may blur the memory” (Mead, 2015, p. 1). Since then, much research has been done to validate White’s thoughts. The 37 studies in the meta-analysis by Cooper et al., (1996) documented summer learning loss from 1919 to 1996 and showed all students lose academic achievement if there are no interventions. Researchers argue that school environments having more influence on math scores rather than reading scores because parents can help through the summer vacation months with reading, but not with math (Murnane, 1975; Phillips et al., 1998). In a 2011 study, Boykin and Noguera showed with some intervention, reading achievement can be maintained and, in some rare instances, improved through summer interventions (p. 96).

Achievement Gap

Based on several demographic factors, some students are subject to more significant achievement loss over summers (Boykin, 2011). Using data from over half a million students from 2008-2012 in grades 2-9 from a Southern state found that students, “on average, lost between 25 – 30 percent of their school-year learning over the summer; additionally, Black and Latino students tended to gain less over the school year and lose more over the summer compared to White students” (Atteberry & McEachin, 2016, p. 35). Black-White differences in summer learning loss may explain the achievement gap throughout the school years (Heyns, 1987; Downey, von Hipple, & Broh, 2004). For example, “Black and Latino students are 26-41 points behind White peers on the Math Achievement Scale Scores” (Boykin, 2011, p. 98). A concern with this data is Spring to Spring tests mask the loss of learning over the summer because it allows students to recover through the school year (Jensson et al., 2014), and students often have different teachers between tests, reducing continuity.

Education for poor and minority children and the potential for summer school to advance educational equality (Borman, 2000) are the most promising interventions to close the achievement gap. Substantial gains have been shown in three-week accelerated summer courses for high schoolers in biology, chemistry, and physics (Augustine et al., 2013). Providing add-on services, which are supplementary programs offered beyond the school day and school year, to all students widens the gap (Alexander et al., 2001) because the strong students get stronger at the same rate or faster than those more at risk. While these achievement gaps continue to grow as students pass through each year of schooling, this gap is driven primarily by different rates of learning during the summer months when students are exposed to vastly different learning opportunities while away from the school environment (Atteberry & McEachin, 2016; Alexander et al., 2007; Cooper et al. 1996; Downey et al., 2004; Downey, von Hippel, & Hughes 2008; Quinn et al. 2016). “Schools account for only a small fraction of differences in pupil achievement," after taking into account socioeconomic backgrounds (Coleman et al., 1966, p. 21).

Summer Interventions

Some studies required students to attend summer school to advance to the next grade, which did not motivate students to do well (Augustine et al., 2013). Assigned to summer school, many students at risk of grade retention did not attend, and those that did attend did not do as well as those that attended voluntarily. Also, Benson et al. (2005) found “students that 'volunteered' to attend did better than those assigned to attend.” Kim and Quinn (2013) found that low-income students benefited most from summer reading programs. A similar study showed 53 percent of students (sample size of 75 students) stayed at their reading level or increased by at least one reading level with an intervention plan that provided access to books and magazine subscriptions. It also found that a two-day literacy camp may reduce or eliminate the summer slide in reading in elementary students (Petty et al., 2017).

The 2013 Rand Report, *Getting to Work on Summer Learning: Recommended Practices for Success,* provides a blueprint for a successful summer school environment including “anchoring the program in evidence-based curriculum, strategies for differentiation, class size recommendations and teacher selection and training” (Augustine et al., 2013, p. xii-xv). These recommendations work for urban and rural students. A 1996 study of students attending a summer program in a rural western state reported “all students improved reading and readiness for school as well as improved attitudes toward reading and school in general. Ninety-seven percent attendance rate and 17.9-37.6 percent reading improvement over pretest” (Cramer & Doresy, 1969). Fitzpatrick et al., 2011, contradicted these results showing summer programs have little effect on improving attitudes toward reading specifically, and school in general.

The best practices for reducing and eliminating summer learning loss are to reduce or eliminate the extensive summer break. Hayes & Grether reported that a seven-month difference in reading achievement between poor and middle-class students in the second grade had widened to two years and seven months by the end of sixth-grade (1983). Moving beyond summer school as a requirement at best or punishment at worst, and creating ongoing, engaging learning activities for students when they are away from school is emerging in schools.

Where as school-based summer learning programs hold promise when they fit the criteria outlined by Augustine et al., they often fail to live up to these expectations. Changes in the student data lack an outcome that would conclude that traditional classroom environments are ideal for tackling summer learning loss. Two important reasons why school-based summer programs can be ineffective are that organizers often struggle to attract high-quality teachers and struggle to appeal to students and families for whom the costs of attending summer school can be high (Denton, 2002). Quantitative data from special interest camps such as those with a STEM focus shows a 3 percent increase from pre/post survey in interest in STEM careers (Mohr-Schroeder et al., 2014) However, these camps are cost-prohibitive and do not always turn summer interest into measurable achievement. There appears to be a need for STEM interventions over the summer as a way to promote reading and, more importantly, math achievement.

A summer home-based intervention program that mails books matched to student reading level and interests may be an effective intervention. With each book, students would receive pre-reading activity in the form of a tri-fold paper and a post-reading comprehension check. Students would be asked to return the tri-fold comprehension check in the mail. Lessons would be delivered before the end of the school year to prepare students to read independently over the summer with the tri-fold scaffold. A recent study, including several randomized trials, found that reading comprehension of low-income students following their participation in this type of intervention was half of a standard deviation (ES=.05 SD) higher on the state reading test (Kim et al., 2016). Home-based programs show more promise and improvement while being up to 75 percent more cost-effective. A randomized trial by Kraft and Monti-Nussbaum of third and fourth graders in Rhode Island sent "text messages that included reminders of available community resources available to students over the summer, ideas for activities to do with children, and information about the value of particular summer learning activities" (p. 5) was even more cost-effective. This study (Kraft & Monti-Nussbaum, 2017) claims it is the first to examine the effects of any text-messaging intervention for parents targeting improved student achievement among elementary school students. The combination of a quick feedback system and an instructional expert can maximize the return on the time investment. Most importantly, “all of the components defining structure, such as clearly defined objectives, assignments, and deadlines, need to be present in order to increase student satisfaction.” (Ferguson, 2010, p. 74).

Feedback

Feedback, defined by Shute (2008), is “ information communicated to the learner that is intended to modify his or her thinking or behavior to improve learning” (p. 153). Feedback is a critical step in the learning process, and with increasingly sophisticated computer software, feedback to students can be given in real-time beyond school hours (Clark & Dwyer, 1998).

Feedback can have a positive and negative effect on student academic growth (Hattie, 2012; Kluger & DeNisi, 1996). Boud and Molloy (2013) stress that effective feedback requires teachers to move from providing information to providing opportunities where students can develop their own abilities to self-regulate, judge their learning, and proactively enlists feedback from others, including the teacher. The current practice of assigning summer math packets without access to self-check answers or communication with teachers for clarification and feedback would not meet Boud and Molloy's criterion. Quality feedback needs to be specific and instructive, delivered as close to the time of submission as possible, and focused on the work rather than evaluative (Hammond, 2015). Assigning summer work packets that may or may not be graded in the fall would not align with Hammond's requirement of real-time feedback that focuses on the work rather than the completion of the work for a grade. Feedback is "a complex multi-dimensional rather than a simple, straightforward phenomenon, and is more effective than leaving students to learn autonomously" (Poulos & Mahony, 2008. p. 145). As technology becomes more ubiquitous among middle school students and free online software can provide opportunities for real-time feedback to students, then more effective summer slide interventions can be deployed.

Summary

Summer learning loss is a phenomenon documented largely in the subject of reading and in early elementary grades. Several demographic factors contribute to the amount of achievement loss over the summer, which may be the greatest factor in the widening achievement gap. Add on services such as summer school may not be effective as the students are unmotivated to learn and see it as a punishment. Summer schools are also costly, have difficulty attracting quality teachers, and may not have quality programming. Methods of engaging summer learning are being explored using text messaging and take home packets, however quality feedback is needed to ensure learning occurs.

Timely feedback is more effective than leaving students to complete work on their own over the summer. Technology is becoming ubiquitous in households and can provide real-time feedback and in turn, motivate student learning over the summer when students are not in school.

Chapter 3: Methodology

Introduction

Students transitioning from fifth-grade to sixth-grade enrolled in participating public and independent schools in the Midwest region participated in a study to determine how student-directed online summer review of math and science concepts may or may not reduce summer learning loss (SLL). Student participants completed a multiple-choice pre-assessment (Appendix IV) in the spring and identical post-assessment (Appendix IV) in the fall in their school environment. All interventions were delivered online. Students within this sample had access to the internet and a computer, tablet, or smartphone over the summer. The students self selected their level of participation in the online intervention, the summer computer-based intervention group completed two or more of the online intervention lessons during the summer months. The control group did not complete any of the online intervention lessons during the summer months. Academic performance on the pre-assessment and post-assessment and the number of units completed were measured to compare the summer computer-based intervention group (SCBI) to a control group. Students logged into a website and completed two lessons of academic review for each of the ten-weeks of summer. Students completed an identical pre-assessment and post-assessment. Student participants were assigned a code to track data to maintain confidentiality.

Delimitations

Students that chose to participate in the SCBI group needed access to a smartphone, tablet, or computer with permission to login to the intervention website two times each week to complete academic tasks. Science and math topics were used exclusively to provide additional practice with feedback on content students learned the previous school year. Socio-Economic Status (SES) data was not collected. Although this research neglects socioeconomic status of participants, it is impossible to ignore that low SES students have a wider achievement gap, which is exacerbated by extended summer breaks (Boykin & Noguera, 2011).

All students represented rising sixth-graders in two separate school districts; one was a public school, and the other was an independent school. This population of convenience had email access to the researcher in their school district and to both researchers through the online intervention program, Go Formative (Formative, 2015). Students completed an identical multiple-choice pre and post-assessment at their home school.

Limitations

The following limitations were considered when completing this study.

1) The researchers were employed by the study school as faculty at the time of the research.
2) Several students who participated in the research were either former or current students of one of the two researchers.

3) The research and data were taken from only one midwestern, suburban public school and one suburban independent or private school.

4) Research was collected over one summer.

5) Lessons which occurred during the online intervention were done independently and not part of a traditional classroom experience between teacher and student.

Assumptions

It is assumed that the control and SCBI groups are similar to each other, the two schools represent the same geographic area and include populations at several socio-economic levels. While not truly random, there were no requirements to enroll in the SCBI group, and other than one school having ten more participants, the numbers were reasonably balanced.

Another assumption is that the students did online work at home without additional support or structure. Students could have worked together on the online intervention, but no students indicated using this group work model.

The third assumption is that the 27-question pre-assessment and post-assessment is a reliable and valid indicator of student performance of fifth-grade math and science. The science questions were taken from a larger end of year survey of knowledge one school had been using for many years. The math questions and problems were taken from Common Core (National Governors Association, 2010) example problems.

Research Design

To maintain the focus of the research questions, the researchers selected a quasi-experimental quantitative study utilizing a population of convenience in order to measure the impact of summer review on student retention of math and science content for the fall. Through this quantitative study, the number of interventions completed by a student over the summer were measured and this quantity was then compared to their performance on both the pre-assessment and the identical post-assessment.

Table 3.1

Using Online Interventions to Address Summer Learning Loss in Rising Sixth-Graders Research Questions and Hypothesis

Research Questions	Hypothesis
R1. What impact does technology intervention have on fifth-grade student retention and achievement in science and mathematics content?	H_1 There is a significant difference between students who practiced math and science through the online intervention and those who did not practice math and science through the intervention. H_{01} There is no significant difference between students who did not practice math and science through the online intervention and those who did practice math and science through the online interevention.

R2. To what degree does the number of lessons completed through the summer technology intervention impact student retention and achievement in science and mathematics content?	H_2 There is a significant difference between students who complete more lessons of the science and math online intervention than students who complete fewer lessons of the science and math online intervention. H_{02} There is no significant difference between students who complete more lessons of the science and math online intervention than students who complete fewer lessons of the science and math online intervention.

Population and Sample

One hundred twenty public and independent school rising sixth-graders in a suburban midwestern city ages 10-12 were used in this sample of convenience. Four students were disqualified for not completing the pre or post-assessment. The population (N=116) includes students taking the pre-assessment and post-assessment. All students chose whether or not to participate in the ten-week technology-based intervention that reviewed fifth-grade science and math content and skills. Students that did not participate in the intervention were the control group (*n*=79). Students that completed two or more lessons during the summer intervention were included in the SCBI group (*n*=34).

Instrumentation

An online pre-assessment was given to the entire sample in May 2019, and an identical online post-assessment was given to the entire sample in September 2019 using Google Forms. The use of the same pre-assessment and post-assessment tests and raw scoring statistics addresses von Hipple's concerns with the Cooper, et al. Beginning School Study using different tests at the end of one year and the start of the next year and the use of different scaling practices to accommodate the change in tests.

The science portion of the assessment was developed using end of year assessment questions from the independent school. These questions were compared to the fifth grade report card indicators for the public school and the two researchers selected questions that covered standards from each school.

The same report card comparison was utilized to identify assessed math standards. Once the standards were identified, assessment questions that focused on the identified skills were used from Math in Focus (Ramakrishnan, 2014).

Only one assessment was developed for the pre/post-assessment, to ensure that the data from pre-assessment to post-assessment is comparable item by item. The math items were selected using the report card indicators at one of the participating schools (See Appendix II), and the science items were selected based on the items covered in science at the Elementary school level (NGSS, 2013).

Ten math lessons and ten science lessons were designed to focus on the key elements assessed on the pre/post-assessment. The lessons were designed to target content that is identified as essential skills for fifth-graders by the Common Core (National Governors Association, 2010) and Next Generation Science Standards (NGSS, 2013). This is determined using curriculum documents from the school districts that participated in the research (Appendix II and III).

Each researcher designed and planned the review for one of the content areas to be posted to the Formative website once a week over the 10-week summer period. Each week of math was designed around an individual math skill, and each week of science was designed around relevant science topics and events from the science standards. For example, moon topics were covered during the week of the 50th anniversary of the moon landing, and equinox and solstice topics were covered during the week of the summer solstice.

Institutional Research Board Approval

Since the data is stored without an identifiable relationship to the research subjects, the study took place as part of an educational setting, made use of common math and science topic questions, and does not fall under any of the standard exceptions, consent, and assent forms were not necessary.

Fifth-Grade Topics

Fifth-grade topics covered in the summer intervention include computational proficiency in operations (addition, subtraction, multiplication, and division) with whole numbers, operations with fractions excluding dividing by fractions, operations with decimals excluding dividing by decimals. These skills were identified as essential by the participating school districts (Appendix II and III).

Fifth-grade science topics include many Earth Science topics consisting of seasons, phases of the moon, plate tectonics, heat transfer, and the scientific method, as stated in the Next Generation Science Standards (NGSS, 2013). The math and science topics given were gleaned from an End of Year Survey of Knowledge commonly given to students at the end of their 5th-grade year.

Methods and Data Collection

The degree of impact of an online intervention on math and science summer learning loss was explored using a quasi-experimental quantitative method.

Google Forms is an online software that allows invited users to answer questions in the survey form and compiles the data for statistical use. Students were asked 27 questions about math and science topics (See Appendix IV).

Formative, also known originally as GoFormative, delivered weekly math and science lessons to student and parent email addresses. The form builder was used to create formative classwork, homework, and assessments each week. Video and reading content was embedded in the lesson assignments, and many questions provided instant automated feedback to students. Student growth was tracked through this online response system. Teacher feedback was provided to specific students several times each week. Students typed, drew, submitted images (Figure 3.1), or submitted a ‘show your work’ screen capture to demonstrate their understanding (Figure 3.2) and were allowed to resubmit their work after receiving feedback (Formative, 2015). Formative gives real-time information on student understanding to more easily provide immediate intervention and support to review math and science concepts.

Figure 3.1

Examples of Student Work in Science

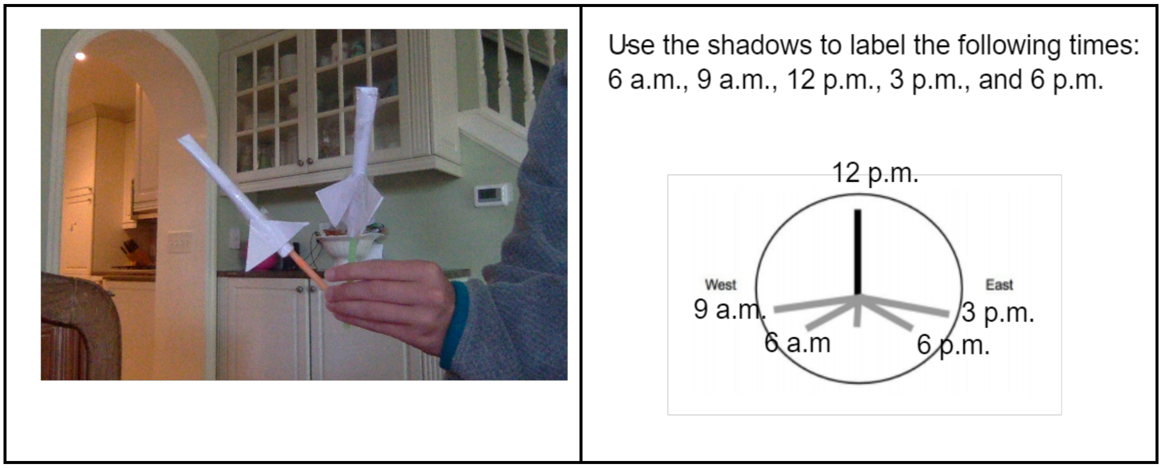
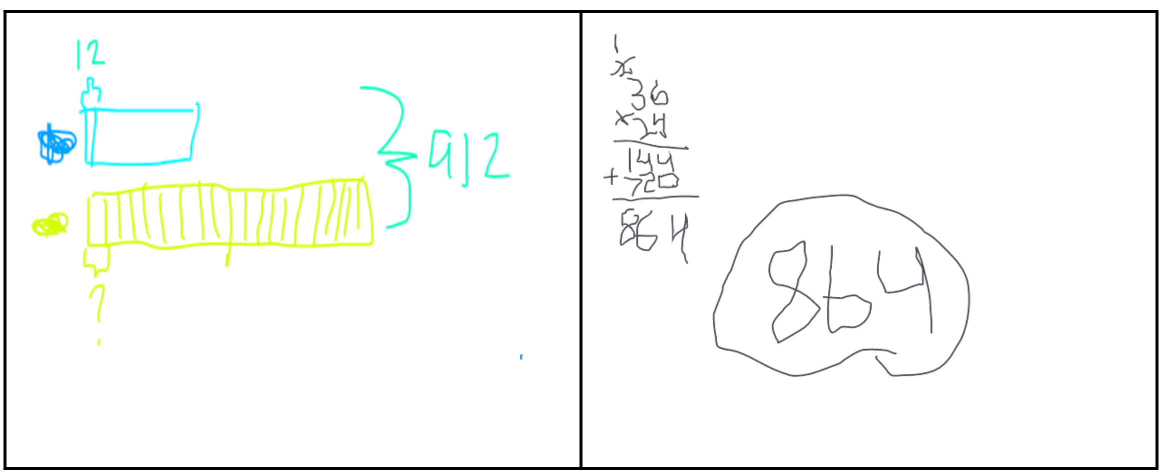


Figure 3.2

Examples of Student Work in Math



Students anonymously signed up to participate in the technology intervention, and there was no compensation for participating in the ten-week technology program. This anonymity reduces the rivalry threat to validity over the ten-week summer intervention while students are out of school.

The researchers had students from their schools involved in the study, so there is an experimenter effect threat to validity. However, no students received any grade for pre-assessment, post-assessment, or participation in the intervention even though sanctioned as part of the school program. The pre-assessment and post-assessment were multiple-choice, which eliminated the threat of inter-rater reliability and bias. In addition, one researcher did not have the participants as assigned students in a formal class at his school during the pre-assessment test period, and the other researcher did not have the participants at his school in an assigned class during the post-assessment test.

Site and Sample Selection

The research was conducted at two schools in the St Louis Metropolitan area, one public, and one independent school. The sample was students transitioning to sixth-grade enrolled in one of these two schools. The students varied in age from ten to twelve at the beginning of the intervention and to eleven to twelve at the end of the intervention. The site and sample were selected because they employ the two researchers and provided a sample of convenience. Only fifth-graders transitioning to sixth-grade participated. The program was offered as an extension of the 2019 school year program.

All students were invited to participate in this summer learning loss program sponsored by each school. Since the end of the year survey of knowledge was common or adopted practice at each school and giving summer work was a common practice at each school, there was no need for parental consent and student assent. All data was stored in a secure location at each of the two schools. All students had the opportunity to participate in the pre-assessment and post-assessment as well as the ten-week technology intervention. Students chose to participate in the study by taking the pre and post-assessments but could choose to not do the ten-week technology intervention. These students became the control group.

Design and Data Treatment

The quasi-experimental design was employed to recognize and understand the causal relationship between the intervention and the retention or loss of knowledge from the previous school year. Unlike most experimental designs, the participants self-selected into the control or test variable population. Technology intervention is the independent variable. A population elected to take part in more than two of the twenty lessons during the ten-week technology intervention reviewing math and science content covered during the previous school year. The control group did not participate in the technology intervention.

The scores of these two groups were compared to determine if the different experiences over the summer possibly influenced the differences in scores. Scores were analyzed by assessing the means for the two groups and then comparing them to determine if there is a significant difference between the groups.

The quasi-experimental design used available populations as part of the normal school year program. Therefore, there is no random assignment of participants and is defined as a quasi-experimental study (Cresswell, 2014).

Quantitative data was obtained through the pre-assessment and post-assessment. The nonequivalent group design where the control and treatment groups completed a pre-assessment and post-assessment, but only the treatment group received the intervention. The groups were not of equal size. All student information and data was referenced by a student number.

In addition to analyzing the basic statistics for each group, an inferential statistics t-test of post-assessment data between control and intervention groups was used to determine where there is a significant difference of the means of the two groups pending normal distribution. A simple linear regression analysis assessed potential correlations between the post-assessment score and the number of lessons attempted by the SCBI group. This addresses the second research question, to what degree does the number of lessons completed through the summer technology intervention impact student retention and achievement in science and mathematics content?

The data was kept in a spreadsheet and imported into Microsoft Excel and IBM SPSS statistics software was utilized to evaluate the data.

Validity

Multiple internal validity strategies were deployed to rule out identified threats to causal inferences such as maturation, testing, instrumentation, and inter-rater variability.

The quasi-experimental treatment was conducted within the last week of one school year and the first three weeks of the next school year, reducing confounding factors such as maturation of the participants. This single factor has been identified as a threat to the validity of standardized testing and rejection of summer learning loss when tests are administered each April (Patton & Reschly, 2013).

Identical pre-assessment and post-assessment make test-retest threats to validity possible, though the assessments cover previously learned materials and not new content. The pre-assessment and post-assessment were administered approximately 14 weeks apart. Questions in the math and science section were covered earlier in the year and appeared on the end of course survey of knowledge at one of the institutions for the last several years (See Appendix II & III).

Instrument

Both groups completed an identical pre-assessment and post-assessment aligned to the reviewed math and science standards presented within the ten-week technology intervention. Participants completed the pre-assessment and post-assessment within the regular classroom environment. The instrument was created to ascertain participant recall of math and science standards from the previous school year. To increase inter-rater-reliability and ease of feedback, the twenty-eight question pre/post-assessment was in a multiple-choice format. All students received feedback from the pre/post-assessment after the post-assessment was administered in late August upon returning to school.

During the ten-week technology intervention, student participation data was collected from Goformative and showed the number of lessons the participant completed in the online environment. The system tracked student completion of tasks, and the investigators provided feedback through Goformative to participants as they completed the weekly tasks.

Summary

The quasi-experimental design was employed to recognize and understand the causal relationship between the intervention and the retention or loss of knowledge from the previous school year. The participants self-selected into the control or test variable population and determined their level of participation. Student participants completed a multiple-choice pre-assessment in the spring and identical post-assessment in the fall as part of the school environment. During the 10-week intervention, all students received separate online weekly science and math lessons reviewing concepts learned the previous school year. The 34 students that completed the lessons using a smartphone, tablet, or computer were the Summer Computer-Based Intervention (SCBI) group and the 79 students that did not do any online lessons were the control group. Students submitted their work through a website and received immediate automated and student-specific feedback from the researchers throughout the week. No data was collected on socio-economic status, gender, standardized testing, or course grades.

Chapter 4: Data Analysis and Results

Introduction

The effectiveness of an online summer review on rising sixth-grade students in mathematics and science, was measured using a quasi-experimental quantitative method. Scores on an identical pre and post-assessment were compared to measure the retention of skills from the fifth-grade spring semester to the beginning of the sixth-grade fall semester. Students self-selected their participation in the study and all students took the assessments. The control group consisted of students that did not participate in the online summer intervention and the SCBI group participated in the program at varying levels.

Results

Hypothesis: H_{01} There is no significant difference between students who did not practice math and science through the online intervention and those who did practice math and science through the online interevention.

116 rising sixth-graders completed the pre-assessment and post-assessment. Students that did not take both assessments or students that completed fewer than two lessons during the summer, were excluded from the data. With the focus on both math and science content retention any students that did not complete at least one math and science review were not included in the data, this removed three students that only completed one lesson during the summer. The assessment data shows that the groups performed similarly on the

pre-assessment and post-assessment. The minimum scores and the maximum scores were exactly the same on the pre-assessment and post-assessment for the overall population. The post-assessment mean was slightly higher than the pre-assessment mean. Inversely, the pre-assessment Standard Deviation was slightly higher than the post-assessment Standard Deviation (Table 4.1).

Table 4.1

Means and Standard Deviations of Scores on Baseline Measures

	N	Range Scores	Mean	Standard Deviation
Pre-assessment	116	7 to 25	18.36	4.51
Post-assessment	116	7 to 25	18.81	4.31

The two-tailed t-test, which tests if the mean is significanly greater than or less than 0, was used to compare the means of the two groups. A p-value less than or equal to 0.05 is considered statistically significant. It indicates strong evidence against the null hypothesis, as there was less than a 5% probability the null is correct. The P-value of the t-test equals 0.0225 and is therefore considered to be statistically significant.

Table 4.2

Statistics Illustrating Change of Score between Pre-assessment and Post-assessment

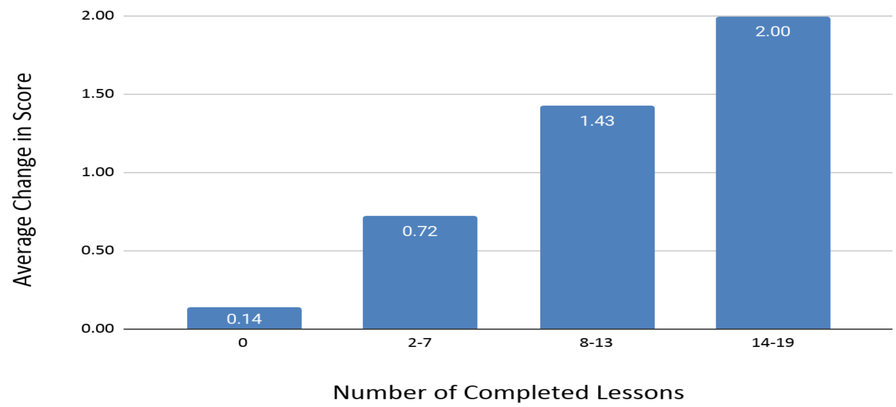
	N	Range Scores	Mean	Standard Deviation
Control Group	79	-5 to 4	0.14	2.04
SCBI Group	34	-3 to 8	1.21	2.01

The unpaired two-tailed t-test was used to compare the change in score from pre-assessment to post-assessment among the control and SCBI groups. A p-value less than or equal to 0.05 is considered statistically significant. It indicates strong evidence against the null hypothesis, as there was less than a 5% probability the null is correct. The P-value of this test equals 0.0119 and therefore was considered to be statistically significant (Table 4.2).

There were 79 students in the control group that completed zero lessons with an average score growth of 0.14. Of the students that completed two or more lessons, the maximum number of lessons completed was 19. With the number of lessons completed covering a range of 18 we split the SCBI group into three equal groups of six lessons. There were 18 students that completed 2-7 lessons with a group average point growth of 0.72, seven students completed 8-14 lessons with an average point growth of 1.43, and nine students that completed 14-19 lessons with a group average point growth of 2.00 from pre-assessment to post-assessment (Figure 4.1). This suggests a correlation between more lessons completed and higher average growth from pre-assessment to post-assessment.

Figure 4.1

Average Change Pre to Post Vs. Number of Lessons



More than half of the SCBI group showed an increase in their score where more than half of the control groups showed no change or a decrease (Table 4.3). The group that completed 8-13 lessons had the highest median, the students in this group gained the most. The group that did not complete any lessons had zero as the median showing this group had the least growth from pre-assessment to post-assessment.

Table 4.3

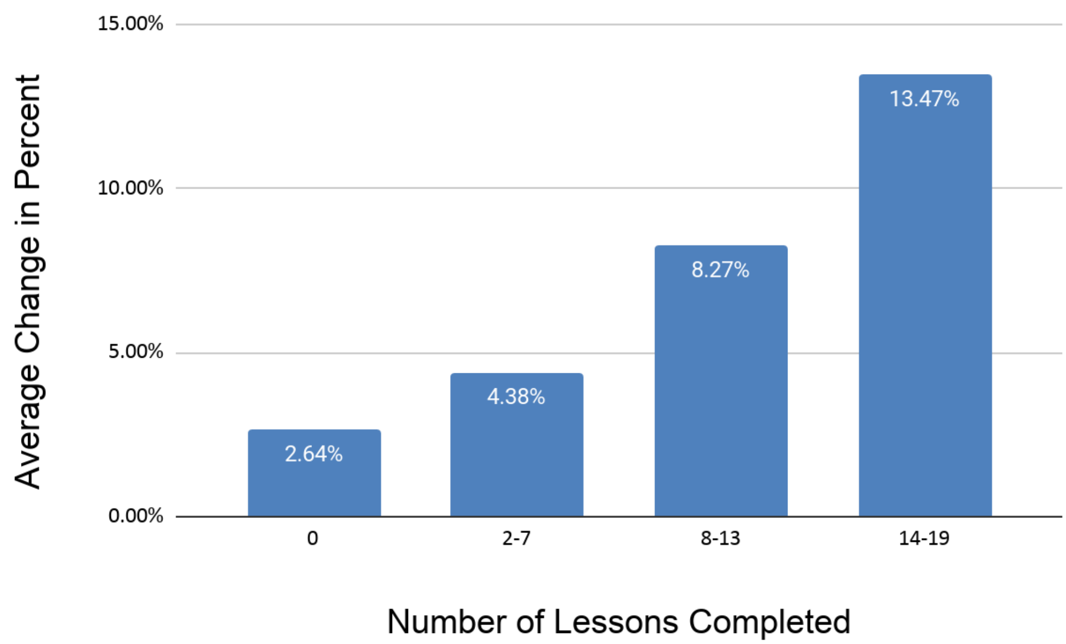
Median Scores and Range of each group

Group	N	Median	Range
Control Group (zero lessons)	79	0	9
SCBI Group 2-7 lessons completed	18	1	7
SCBI Group 8-13 lessons completed	7	2	3
SCBI Group 14-19 lessons completed	9	1	9

The 79 students in the control group had a 2.64% change from pre-assessment to post-assessment. There were 18 students that completed 2-7 lessons with a 4.38% change from pre-assessment to post-assessment, seven students completed 8-14 lessons with a 8.27% change from pre-assessment to post-assessment, and nine students that completed 14-19 lessons with a 13.5% change from pre-assessment to post-assessment (Figure 4.2).

Figure 4.2

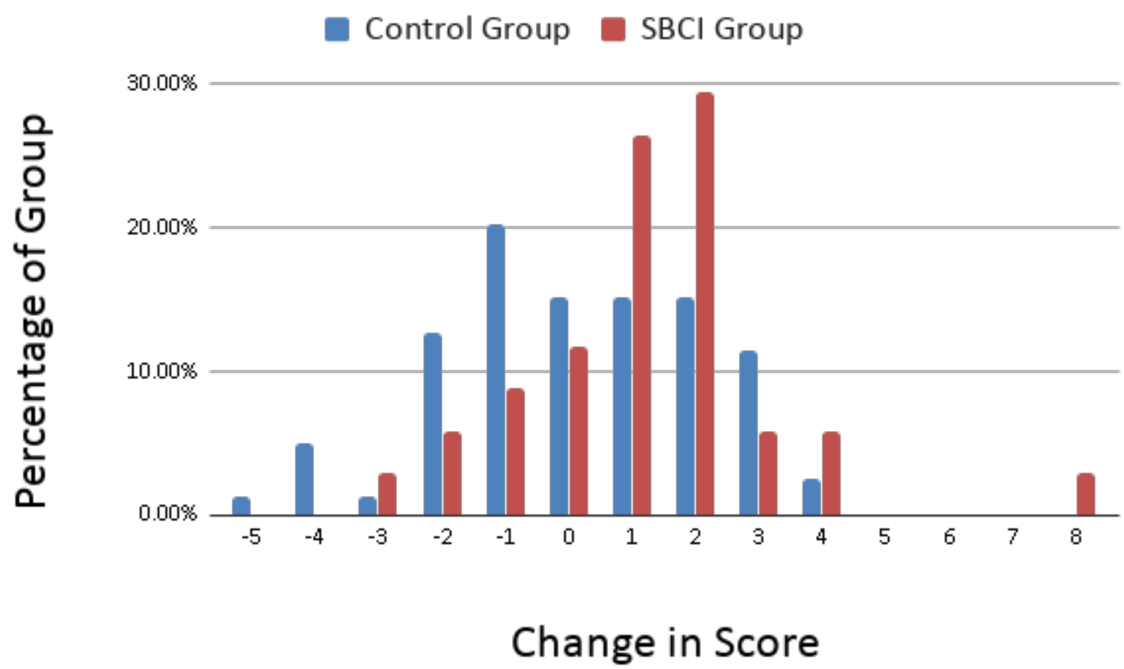
Percent Change of Assessment Scores Based on Lessons Completed



Of the 79 students in the control group, 32 students scored lower on the post-assessment than the pre-assessment. Twelve students scored the same on the pre and post-assessment, and 35 students scored higher on the post-assessment than the pre-assessment (Figure 4.3).

Figure 4.3

Percentage of Students at Each Level of Change from Pre-Assessment Score to Post-Assessment Score



Of the 34 students in the SCBI group, 82.4% showed no change or increased their score from the pre-assessment to the post-assessment. Six students in the SCBI group scored lower on the post-assessment than the pre-assessment. Four students in the SCBI group scored the same on the pre-assessment and post-assessment, and 24 of the 34 students in the SCBI group scored higher on the post-assessment than the pre-assessment (Figure 4.3). In the SCBI group, 12% of students scored lower on the post-assessment than the pre-assessment where 40.5% of students in the control group scored lower on the post-assessment than the pre-assessment (Figure 4.3).

Summary

116 rising sixth-graders completed the pre-assessment and post-assessment. Students that did not take both assessments and students that completed fewer than two lessons during the summer were excluded from the data. The unpaired two-tailed t-test was used to compare the change in score from pre-assessment to post-assessment among the control and SCBI groups. The P-value of this test equals 0.0119 and is considered to be statistically significant. Of the 79 students in the control group, 32 students scored lower on the post-assessment, 12 students scored the same on the pre-and post-assessment, and 35 students scored higher on the post-assessment. Of the 34 students in the SCBI group, six students scored lower on the post-assessment, four students scored the same, and 24 of the students scored higher on the post-assessment.

Chapter 5: Discussions and Conclusions

Introduction

The 2010 edition of Clauss-Ehlers Encyclopedia of Cross-Cultural School Psychology explains summer learning loss:

> "Researchers have found that, during the summer, children experience learning loss as measured by differences in grade-level equivalent scores between the end of one school year and the beginning of the following school year. Some researchers have estimated a learning loss of one-tenth of a standard deviation between spring and fall achievement scores, or 1-month of instruction on a grade equivalent scale" (Maríñez-Lora & Quintana, 2010).

Summer Learning Loss continues to impact the academic progress of students over time though the literature is mixed regarding the impact on different socio-economic groups and students at different age levels (Entwisle & Alexander, 1992). Using online interventions to address summer learning loss in rising sixth-graders was implemented in a public school and an independent school in the Midwest from May to September in 2019. A sample population of 116 students completed a pre-assessment covering selected math and science content and math and science skills addressed during the fifth-grade year. All students had the option of participating in a weekly online intervention consisting of one math and one science lesson per week over a ten week period.

Two separate groups were established based on participation in the online intervention. The control group consisted of 79 students that did not participate in two or more online lessons over the summer. The SCBI group included 34 students that participated in two or more of the 20 available lessons over the summer.

In previous years, each school provided a take-home summer packet of math problems as summer practice and review. This non-mandatory review provided students with no feedback and no score for completing the paper packet review. With little oversight, students had less incentive to complete this work and learn from the experience.

The online intervention was provided as a cost-effective method to reach students who wished to practice math and science skills during the summer months. Also, avoiding the time and space costs or constraints of a camp and the summer school model. In addition, delivering the parsed out review on a weekly basis provided students an opportunity to review over the entire summer session in short bursts or in longer sustained sessions without the risk of missing a day or a lesson because of an absence or illness. Lastly, the online environment provided students a location to access continued review even once they completed the individual lessons through other online portals that delivered practice problems with immediate feedback.

The online intervention lessons did not include enrichment activities beyond alternative methods for reviewing and reteaching the targeted fifth-grade content. Using Lave’s (2016) situated learning theory as a framework, challenging hands-on applications of science included; setting up and running an experiment with straw rockets, making a sundial during the summer equinox, and interviewing a friend or relative about the 1969 moon landing. Regarding science as a human endeavor provided context for the activities and learning. Each topic covered in the intervention connected to a Next Generation Science Standard (NGSS, 2013) or Common Core Math Standards (National Governors Association, 2010) covered in fifth-grade.

Research Questions

Research Question 1: What impact does technology intervention have on fifth-grade student retention and achievement in science and mathematics content?

Figure 4.1 shows the statistically significant analysis indicating the technology intervention had a positive impact on student retention and achievement in science and mathematics. This rejects null $Hypothesis_{01}$: There is no significant difference between students who did not practice math and science through the online intervention and those who did practice math and science through the online interevention.. The data indicates that 82% of students that participated in two or more of the intervention lessons did not show summer learning loss.

Research question 2: To what degree does the number of lessons completed through the summer technology intervention impact student retention and achievement in science and mathematics content?

The summer intervention data reflects the more lessons the students finished, the higher their score on the post-assessment (Figure 4.2). This rejects the null $Hypothesis_{02}$: There is no significant difference between students who complete more lessons of the science and math online intervention than students who complete fewer lessons of the science and math online intervention. Students that completed 14-19 of the intervention lessons improved their score by 13.5% on the post-assessment. This percentage was more than a letter grade improvement using a 100 point scale.

General Discussion

Not all students in the SCBI group improved their scores, and not all students in the control group decreased their score. However, the mean score of the change from pre-assessment to post-assessment was 1.21 compared to the mean score of the control group of 0.14. The results were determined to be statistically significant with a small sample of 116 students, the intervention seems promising though other factors may be influencing the results.

The second research question addresses total lessons assuming more lessons would take more time. Although, one student may have completed a lesson in the same amount of time that another student completed two lessons, due to limitations of the software, the amount of time students spent in the lessons was not considered.

The findings are consistent with Barbara Heyns' research on reading in *Summer Learning and the Effects of Schooling* (1978), "irrespective of social class background, the number of books read and the amount of time spent reading consistently influenced summer achievement (p. 191). The theoretical framework of Entwisle's Faucet Theory, "When school was in session, the resource faucet was turned on for all children, and all gained equally; when school was not in session, the school resource faucet was turned off, and so their children's achievement reached a plateau or even fell back," (Entwisle et al., 2014). This framework supports our results as students in the intervention group did not slide back, but many advanced their knowledge on the post- assessment when compared to the control group. This type of intervention blurs the line between school and home resources as the school provided the online resources and opportunity, but families provided the time, focus, and electronic device to participate in the intervention.

Further blurring the line between school and home, students were able to communicate with teachers throughout the summer through email or the GoFormative website. Some students requested help from a teacher with specific questions, and others requested a 'redo' on a formative feedback assessment. All students could retake these assessments multiple times. This extra practice, coupled with immediate feedback on many of the auto-graded quiz-type questions, allowed students to self-assess and seek help if they wished. Other questions were marked by the teachers several times each week, and students received written feedback. This specific, instructive, and real-time feedback model fits Hammond's (2015) assertion that low stakes practice provides longer-lasting learning.

Figure 4.3 shows that 41% of students in the control group scored lower on the post-assessment, where 18% of the SCBI group scored lower on the post-assessment. This analysis between groups demonstrated a positive result of the online intervention when students participated in two or more online lessons.

This intervention has shown that students' performance are equal to or better on a post-assessment when compared to the pre-assessment when weekly online interventions occur throughout the entire summer. Figure 4.1 shows students that did not participate in the intervention had an overall average of 0.14 point increase from pre-assessment to post-assessment where the SCBI group data shows an increase of two full points from pre-assessment to post-assessment suggesting, on average, the more online lessons taken, the higher the post-assessment score.

The data suggests that more intervention experiences result in more improvement in the post-assessment scores. It does not determine why this occurred. The review was helpful to many, but it was undetermined if this was due to contact with the content throughout the summer, remembering, or the time spent on the targeted skills resulting in re-learning. When assessing the results from this investigation, it was essential to remember that socio-economic factors were not part of this study. The researchers believe that all families had access to a smartphone, tablet, or computer throughout the summer to do the online lesson, though this was not confirmed. The researchers sent a weekly email reminder to all students and parents announcing the availability of lessons each week, and all lessons once posted, were available during the entire ten-week period.

Unintended outcomes of the investigation included additional opportunities to come into contact with future students. Communicating with rising sixth-grade students the summer after fifth-grade provided an opportunity to bridge fifth-grade content and establish relationships upon entering sixth-grade. Students were able to learn virtual skills (asking for help, keeping a schedule, self-motivation, self-assessment) through this online intervention. This intervention may be the first time students experienced these types of online academic lessons which provides experience for further encounters.

An additional opportunity that has come from this project was an expansion of the model in both schools. The public school will continue with the summer math intervention after fifth-grade and extend the program to third and fourth-grades. The math and science intervention with students the summer before fifth, sixth, seventh, and eighth grades will continue at the independent school in the coming years. Both schools are replacing the summer math packet with this online intervention.

Conclusions

More online intervention experiences over the summer improve performance on the post-assessment provide promising mechanism for preventing summer slide. An inexpensive software program that provides both real-time and individualized feedback of review topics in math and science over the summer break is a cost-effective and time-effective intervention strategy for reducing summer learning loss. Though the program took some time to set up for this fifth-grade review over the ten-week intervention period, the results were worth the investment, and a template now exists for use in additional grade levels.

With 29% of the available students participating in the intervention, it is vital to increase the intervention participant population. The remaining 71% of the students would likely benefit from the intervention. Expanding the model to include more grades and more teachers monitoring summer online interventions would be a way to increase the effectiveness of this intervention and prevent the necessity for relearning and reteaching.

Suggestions for Future Research

With the annual concern of summer learning loss and higher costs of interventions like camps and summer school, many possibilities exist for future research to reduce summer learning loss. A follow-up study with more participants would determine if these results are reliable, valid, and more broadly applicable. Increasing participant participation through parent and school-wide education efforts may also enhance this specific intervention strategy.

Developing a more complex intervention model where students take the pretest and receive results that allow content specific interventions may provide a greater effect. Students would access a prescribed review during the summer that meets their specific areas of need. Students could choose the lessons that focus on areas where they need more practice/re-teaching.

In general, more rigorous research on extended learning opportunities throughout the summer is needed. Many current interventions and strategies like camps and assigned summer school lack methodological rigor and overall quality. Larger-scale studies across many schools with many different demographic combinations would confirm these results across multiple geographic regions may be more applicable to different populations. Also, more extensive studies provide insight into subgroup differences and needs.

Software that includes artificial intelligence that would adjust the next intervention path based on correct or incorrect answers on previous questions may also be a way to individualize the experience for students and enhance effectiveness. Other advancements in low-cost software and hardware technologies may also allow for more widespread adoption of similar research in the future. This would require a more standardized tool that could easily compare a pre-assessment to a post-assessment.

Recommendations

The current model of the annual cross-sectional measurement of achievement is not sufficient. Student achievement should be measured in the Fall and Spring to account for summer learning loss and gain over the school year (Patton & Reschly, 2013). Intervention plans can be leveraged throughout the school year to meet students where they are when they arrive in the fall. Spring testing will reflect overall student growth and targeted skill areas.

Research on summer learning loss in upper elementary grades when students can differentiate between procedural knowledge and conceptual knowledge should also be studied. Studying the impact of feedback through the summer break to reduce summer learning loss is also an area for future study.

Standardizing the Model

Using online interventions to address summer learning loss can be used as a model in most upper elementary and middle school grades. Participation should be promoted well before the end of each school year citing summer learning loss statistics and successes of this recent intervention. This promotion should also include the need for students to have access to a smartphone, tablet, or computer for up to an hour each week to complete the lessons. Public libraries, schools, and parent employment locations may also have resources for students to use throughout the summer for this purpose. If this pre-assessment, online intervention, post-assessment model is part of the school curriculum and protocol, there is no need for an Internal Board of Review approval.

Mathematics and Science skills and topics specific to the current school year should be consolidated and articulated to a Common Core and NGSS standard respectively. A pre-assessment should be developed and administered before the end of the school year. This same assessment should be given upon students returning to school in the fall, so a partnership should be developed with the teachers a grade level below and a grade level above to carry out this assessment cycle. Once this assessment is developed and proven reliable, it can be used for several years. Take care to make sure students are coded in the same way on the pre-assessment, intervention, and the post-assessment, so the scores can be compared. It is recommended that an auto-grading assessment tool such as a learning management system or free tool such as google forms be used to gather data on students and groups of students efficiently.

A lesson for math and a lesson for science should be developed for each week the students are out of school. A school learning management system or third party website could be used to administer the intervention, but opportunities for immediate feedback (auto-grading) and timely feedback written by the teacher should be an intuitive part of the online experience for students. Lessons should stress as many hands-on experiences as possible, getting students outside, interacting with others through the content, real-world applications, or observing phenomena in the world as possible. Opportunities for students to submit photos of their work, experiences, or products is also recommended. Each week an email or text communication should be sent to students and parents reminding them of the summer intervention opportunity and how to login. Each week new science and mathematics lessons become available and previous week's lessons remain open, so all students can begin the lessons at any point in the summer, though they can only work up to the current week until new lessons are released.

Each week the teacher monitors the progress of those participating in the intervention and provides written feedback and encouragement to students that is specific to their submissions. The whiteboarding features available on many websites allows for students to show their work. The teacher may also create a (smartphone) video, use video software to re-explain something, or provide a link to an online resource if needed.

Upon returning to school in the fall, students will take the same online assessment they completed in the spring. Take care to make sure students that took the pre-assessment are coded in the same way on the interventions and the post-assessment, so the scores can be compared. Students that only took the pre-assessment and post-assessment are the control group. Students that took the pre-assessment, completed two or more of the interventions, and took the post-assessment are the SCBI group. Students that took either the pre-assessment or the post-assessment should be excluded from the control and SCBI groups.

Summer learning loss intervention is part of the curriculum so the pre-assessment and post-assessment scores should be compared, but not used as part of a grading model as it bridges two school years. Post-assessment scores should be reported to students and families with general statistics regarding the control and intervention group. Additional statistics can be calculated regarding number of online intervention lessons completed compared to change in score from pre-assessment to post-assessment. This may be a topic during the fall parent conferences.

This online intervention to address summer learning loss model can be built out over successive years or launched as a school-wide initiative seeking to strengthen the relationship between school and home over the summer. This intentional hand-off of students each year sends a strong message of support from the outgoing teacher(s) and provides a way for the next teacher(s) to welcome students entering the next grade level. This works with grade level matriculation within a building, as a transition from elementary to middle school, and with grade-specific center models.

Although there is a time commitment to develop the lessons, this could be done during the school year as part of regular curricular planning, school improvement planning, professional development, or as a stipended additional task for task force or curricular group. Additional costs may come from the teacher time investment or through a monthly fee for a third party website interface. The combined total costs of all these potential expenses will still likely be less expensive than one full day of face to face summer school when staffing, facilities, bussing, and food service costs are incurred.

Summary

The online intervention provided a cost-effective method to reach students who wished to practice math and science skills during the summer months. Using Lave's Situated Learning Theory framework, students received feedback on the challenging hands-on applications of science and math lessons they completed, and what Entwisle calls the 'faucet' of learning resources was open and flowing over the 10-week summer break. The data indicates 82% of the students that participate in two or more of the intervention lessons did not show summer learning loss. The intervention data also reflects on average, the more lessons students completed, the higher their score was on the post-assessment. Students that completed 14-19 of the 20 lessons improved their score by 13.5%. The study will continue for another year and expand grade level participation seeking a greater number of participants. Standardizing the model will be an additional next step.

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Appendix I - IRB Exempt

Following up on IRB message-reply Granger: UMSL ×

Granger, Charles <grangerch@umsl.edu> Fri, Oct 11, 7:01 AM
to me, Scott

Good Morning Bob & Scott:

You are ready to go. See below.

Chuck.

From: Paulette Issac-Savage <EPIsaac@umsl.edu>
Date: Wednesday, October 9, 2019 at 5:20 PM
To: "Granger, Charles" <grangerch@umsl.edu>
Subject: RE: Following up on IRB message-reply

Yes. They can move forward. The data was already collected, based on what I read. There are no identifiable data. They are analyzing the data now. If they were collecting data and using surveys they would then seek exempt approval.

Dr. E. Paulette Isaac-Savage
Professor, Adult Education
IACE Hall of Fame 2019 Inductee
214 Marillac Hall
University of Missouri-St. Louis
1 University Boulevard
St. Louis, MO 63121
(314) 516-5303 (office)

Appendix II - Math Report Card Indicators

Math 5

STANDARDS

C5.MA.MD - If marked, student receives modified instruction and assignments

C5.MA.BT.01 - Understand place value from the billions to the thousandths

C5.MA.BT.02 - Use properties of operations to perform operations on multi-digit whole numbers to billions and decimals to thousandths

C5.MA.NO.01 - Understand the relationship between fractions and decimals (denominators that are factors of 100)

C5.MA.NO.02 - Perform operations and solve problems with fractions and decimals

C5.MA.AI.01 - Represent, analyze and interpret patterns and expressions

C5.MA.AI.02 - Use the four operations to represent and solve problems

C5.MA.GE.01 - Classify two- and three-dimensional geometric shapes

C5.MA.GE.02 - Understand and compute volume

C5.MA.GE.03 - Graph points on the Cartesian coordinate plane within the first quadrant to solve problems

C5.MA.GE.04 - Solve problems involving measurement and conversions within a measurement system

C5.MA.DP.01 - Represent and analyze data

Appendix III - MICDS Science Competencies

Exhibits knowledge of the Earth’s layers, their interactions, and how the heat transferred through these layers result in many of Earth’s natural processes

Demonstrates an understanding of the states of matter and the causes of their changes

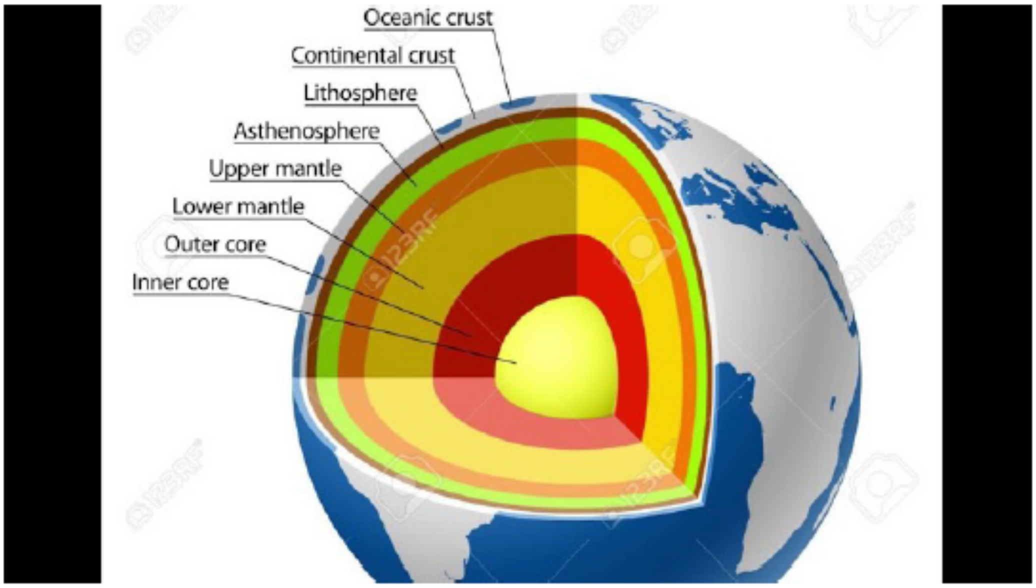
Connects the Earth’s position and movement in space to everyday conditions, moon phases, and eclipses

Develop and use a model of the Earth--sun--moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

Identifies key objects in our solar system by their features, conditions, and locations

Appendix IV Pre-Assessment and Post Assessment

2. This type of heat transfer in the asthenosphere causes the pieces of Earth's lithosphere, called tectonic plates, to move. * 1 point



Mark only one oval.

- ◯ convection
- ◯ conduction
- ◯ radiation
- ◯ revolution

3. What two main factors determin an object's state of matter? * 1 point

Mark only one oval.

- ◯ electricity and density
- ◯ plasma and magetism
- ◯ temperature and pressure
- ◯ solid and liquid

4. Heat transfer between particles that are in direct contact, or touching, is called * 1 point

Mark only one oval.

- radiation
- conduction
- convection
- rotation

5. When conducting a scientific investigation, like an engineering design challenge, what is the first step you should take? * 1 point

Mark only one oval.

- Pose a question or problem that needs to be solved
- Draw conclusions from observed data.
- Form a hypothesis about what you think will happen in the experiment.

6. Day and night are caused by * 1 point

Mark only one oval.

- ⬭ Earth's rotation on its axis.
- ⬭ solar and lunar eclipses.
- ⬭ Earth's revolution around the sun.
- ⬭ the tilt of Earth's axis.

7. Earth has seasons because * 1 point

Mark only one oval.

- ⬭ Earth's axis is tilted as it revolves around the sun.
- ⬭ Earth rotates on its axis.
- ⬭ the distance between the Earth and the sun changes.
- ⬭ the temperature of the sun changes.

8. Which two important factors cause warmer temperatures during the summer season for us in the northern hemisphere? * 1 point

Mark only one oval.

- ⬭ The northern hemisphere receives more direct sunlight & has more hours of daylight.
- ⬭ The Earth is farther from the sun & days are longer.
- ⬭ The sun gets hotter & the Earth gets closer to the sun.
- ⬭ The Earth gets closer to the sun & the northern hemisphere receives more direct sunlight.

9. Solstices marks the beginning of which two seasons? * 1 point

Mark only one oval.

- summer and winter
- spring and fall
- spring and summer
- fall and winter

10. An equinox occurs when * 1 point

Mark only one oval.

- neither end of the Earth's axis is tilted toward or away from the sun.
- the north end of the Earth's axis is tilted away from the sun.
- the north end of the Earth's axis is tilted toward the sun.
- Earth's axis is parallel to the sun's rays.

11. The phase of the moon you see depends on * 1 point

Mark only one oval.

- how much of the sunlit side of the moon faces the Earth
- how much of the Earth's shadow is cast on the moon.
- the tilt of Earth's axis as it revolves around the sun.
- how much of the moon's surface is lit by the sun.

12. Which moon phase occurs directly after a full moon? * 1 point

Mark only one oval.

- Waxing Gibbous
- Waning Gibbous
- Waxing Crecent
- Waning Crecent

13. For a solar eclipse to occur * 1 point

Mark only one oval.

- the moon must be directly behind the Earth.
- Earth must be directly between the sun and moon.
- the moon must be directly between Earth and the sun.
- the sun must be directly between Earth and the moon.

Math

14. Divide 4,825 by 23. * 1 point

Mark only one oval.

- 29 R 18
- 117 R 1
- 203 R 25
- 209 R 18

15. * 1 point

Evaluate $(45 - 21) \div 8 + 2$.

Mark only one oval.

- 5
- 7
- 8
- 12

16. *

1 point

What is the value of $\frac{7}{10} - \frac{3}{6}$?

Mark only one oval.

$\frac{1}{15}$

A

$\frac{2}{15}$

B

$\frac{1}{5}$

C

1

D

17. * 1 point

Which fraction has the same value as $\frac{3}{5} + \frac{1}{3}$?

Mark only one oval.

$\frac{2}{15}$	$\frac{4}{15}$
A	B
$\frac{1}{2}$	$\frac{14}{15}$
C	D

18. * 1 point

$$1\frac{2}{5} + 5\frac{3}{10} =$$

Mark only one oval.

$6\frac{1}{2}$	$6\frac{7}{10}$
A	B
$7\frac{1}{2}$	8
C	D

19. Which of these decimals is the greatest? * 1 point

Mark only one oval.

- 21.07
- 2.107
- 1.973
- 27.6

20. Write 6.04 as a mixed number in simplest form. * 1 point

Mark only one oval.

$6\frac{2}{5}$	$6\frac{1}{25}$
A	B
$6\frac{4}{100}$	$6\frac{64}{100}$
C	D

21. Multiply 2.68 by 8 * 1 point

Mark only one oval.

- 2.144
- 21.44
- 214.4
- 2,144

22. Divide 72.38 by 70 * 1 point

Mark only one oval.

- 1.034
- 1.304
- 10.34
- 103.4

23. * 1 point

$$90 \div (15 - 13) + 6 = ?$$

Mark only one oval.

- 1
- 45
- 48
- 51

24. Of the 250 people at a concert, 150 are men. One fourth of the rest of the people are children. How many of the people are women? * 1 point

Mark only one oval.

- 25
- 50
- 75
- 100

25. *

1 point

Find $\frac{3}{4}$ *of* $\frac{8}{9}$

Mark only one oval.

$\frac{2}{9}$

A

$\frac{1}{3}$

B

$\frac{1}{9}$

C

$\frac{2}{3}$

D

26. If 5 laps around the track is 3.65 kilometers, how many kilometers is 20 laps around the track? * 1 point

Mark only one oval.

- 0.73 km
- 1.46 km
- 14.6 km
- 146 km

27. * 1 point

Divide $\frac{2}{5}$ *by* 4

Mark only one oval.

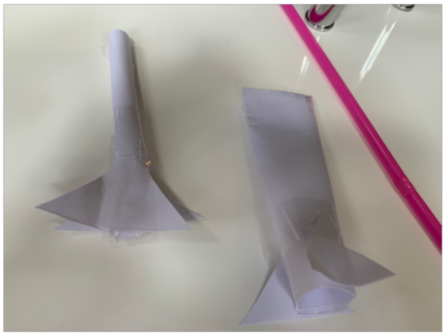
$\frac{8}{5}$	$\frac{1}{10}$
◯ A	◯ B
$\frac{1}{2}$	$\frac{1}{5}$
◯ C	◯ D

28. Divide 354 by 15. Choose all that apply. * 2 points

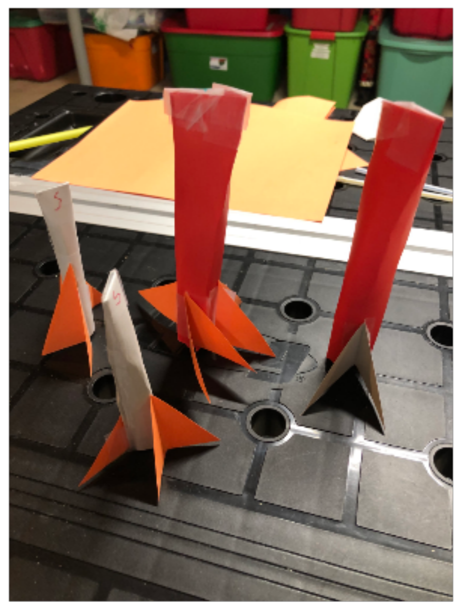
Check all that apply.

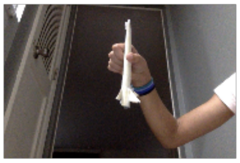
23.6	23.06
☐ A	☐ B
$23\frac{3}{50}$	$23\frac{3}{5}$
☐ C	☐ D

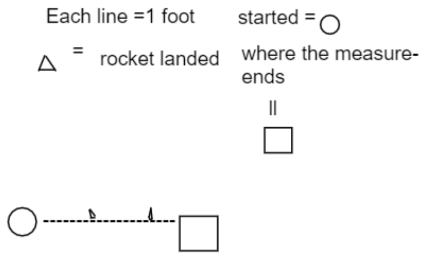
Appendix V - Student science work submitted Through Go Formative



I started on this side







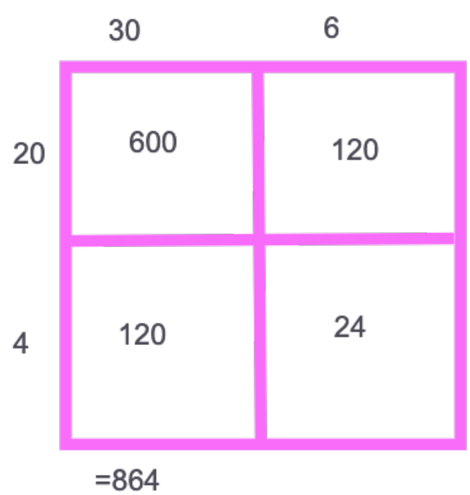
Draw how the Sun, Earth, and Moon would be situated during a New Moon

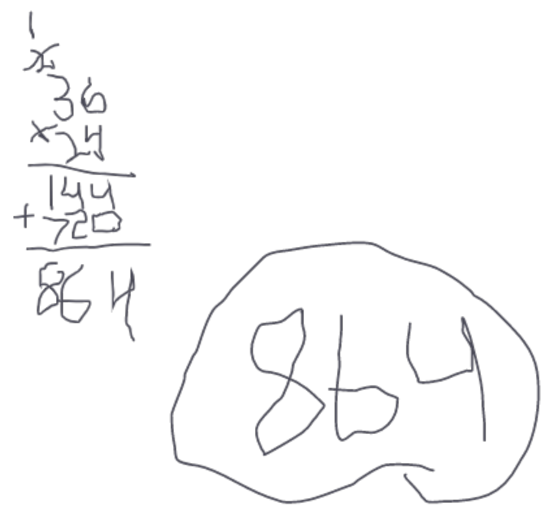
Talk to a relative, family friend, or neighbor about what they know about the Lunar Landing. Summarize what they told you into a paragraph about the Lunar Landing in 1969. Be sure to share what you know about the sun, moon and Earth with them!

It was an amazing time in our earth's history. It was when people among Neil Armstrong (I think) walked on the moon for the first time in history. It happened on July 16, 1999 when Neil Armstong and others took off on the Apollo 11. It took years of preparation and reserch and it was all worth it in the end. The US and Russia where competing to be the first to get to the moon and the US ended there first. The Austronuts were called heros.

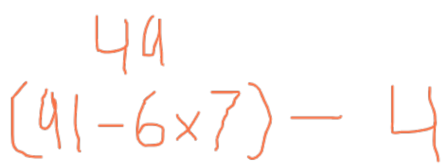
Appendix VI - Student mathematics work submitted through Go Formative

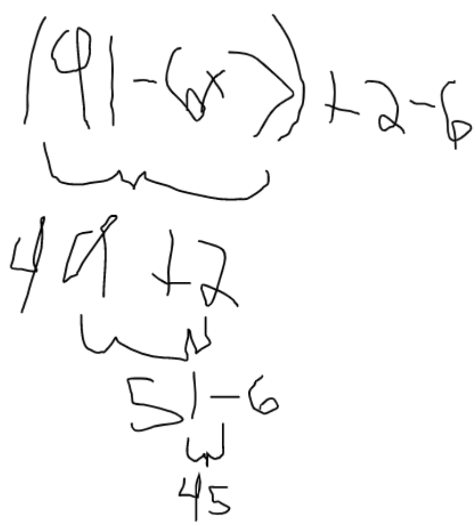
For the question: 24 x 36 =





For the question: (91-6x7)+2-6





Appendix VII - Raw Pre-Assessment and Post-Assessment Data with Number of Completed Lessons

Pre	Post	# of Completed Lessons
21	16	0
22	18	0
25	21	0
21	17	0
23	19	0
23	20	0
20	18	0
13	11	0
24	22	0
21	19	0
19	17	0
21	19	0
20	18	0
19	17	0
11	9	0
22	20	0
8	7	0
17	16	0

Pre	Post	# of Completed Lessons
20	19	0
21	20	0
13	12	0
23	22	0
20	19	0
20	19	0
23	22	0
21	20	0
20	19	0
24	23	0
23	22	0
20	19	0
20	19	0
23	23	0
7	7	0
19	19	0
19	19	0
23	23	0

Pre	Post	# of Completed Lessons
18	17	0
19	19	0
20	20	0
23	23	0
23	23	0
15	16	0
7	8	0
7	8	0
21	22	0
19	20	0
9	10	0
14	15	0
19	20	0
19	20	0
22	23	0
8	10	0
8	10	0
19	21	0
18	20	0
7	10	0
17	20	0

Pre	Post	# of Completed Lessons
20	20	0
22	22	0
15	15	0
15	16	0
20	21	0
20	22	0
20	22	0
18	20	0
15	17	0
20	22	0
22	24	0
18	20	0
21	23	0
19	22	0
20	23	0
19	22	0
9	12	0
12	15	0
20	23	0
18	21	0
19	23	6

Pre	Post	# of Completed Lessons
8	12	0
18	22	0
11	8	1
23	24	1
20	22	1
24	22	2
22	21	2
11	11	2
21	22	2
21	22	2
18	19	2
23	23	3
16	18	3
25	22	4
21	22	4
20	18	5
15	16	6
18	20	6
18	20	6

Pre	Post	# of Completed Lessons
21	22	7
22	24	7
17	20	7
20	22	8
12	14	8
22	21	11
17	19	11
19	21	11
23	25	12
21	22	13
9	11	14
14	22	14
20	20	15
17	16	17
19	22	17
21	22	18
20	21	18
22	22	19
18	22	19