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Technology, Mathematics and the Flourishing of the Elementary Student

Judy de Waal

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Abstract

This action research study investigated the effects of using technology as part of the instruction and implementation in a primary mathematics classroom, determining if such technology would make a difference in increased student performance. The participants were 71 first grade students, 32 making up the control group, and 39 involved in the experimental group. The experimental group spent 40 minutes per week using a technology-based platform as part of their math instruction. They also had access to this technology outside of school. All students were given a pre- and post-test to determine growth in their learning. The results of this study demonstrated that although academic growth was evident in both groups, students who had the availability to enhance their learning with technology within and outside the classroom experienced considerably more growth in their learning while spending more time engaging in authentic and personalized mathematics instruction.

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Technology, Mathematics and the Flourishing of the Elementary Student

By

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Action Research Report
Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Education

Department of Education
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Sioux Center, Iowa

April, 2015

Technology, Mathematics and the Flourishing of the Elementary Student

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Abstract

This action research study investigated the effects of using technology as part of the instruction and implementation in a primary mathematics classroom, determining if such technology would make a difference in increased student performance. The participants were 71 first grade students, 32 making up the control group, and 39 involved in the experimental group. The experimental group spent 40 minutes per week using a technology-based platform as part of their math instruction. They also had access to this technology outside of school. All students were given a pre- and post-test to determine growth in their learning. The results of this study demonstrated that although academic growth was evident in both groups, students who had the availability to enhance their learning with technology within and outside the classroom experienced considerably more growth in their learning while spending more time engaging in authentic and personalized mathematics instruction.

Keywords: Technology and Mathematics

In the majority of homes today, children are growing up in a world where smartphones, Internet connections and videogame consoles are readily available to them.

> The numbers are overwhelming: over 10,000 hours playing videogames, over 200,000 emails and instant messages sent and received; over 10,000 hours talking on digital cell phones; over 20,000 hours watching TV, over 500,000 commercials seen – all before the kids leave college. And maybe, at the very most, 5,000 hours of book reading. These are today's "Digital Native" students. (Prensky, 2001, p.1)

For the most part, educational settings have many forms of technology available to them, and yet many educators remain steadfastly lodged in teaching methods that are familiar to them as "digital immigrants," but are not necessarily effective for their students. Despite decades promoting educational uses of technology, classroom practice in most schools has changed little from that of the mid-20th century (Means, 2010, p. 285). Teachers still talk about "doing a technology lesson" as though teaching with technology is somehow different from real teaching. After many years, the process of integrating technology with content area instruction remains a mystery to many teachers (Hamilton, 2007). One of the main challenges for education systems today is to leverage the learning sciences and modern technologies to develop engaging, authentic, and personalized learning experiences (Rosen & Beck-Hill, 2012, p. 225).

Educators will agree that students learn in different ways in a classroom environment, differing in the ways they perceive and comprehend information and requiring very different ways of approaching and understanding content. The traditional medium of print is too limiting to meet the challenges of diverse learners' needs, and classroom teachers must employ materials that have multiple representations (e.g. text, video, animation/simulation, audio) and varied difficulty levels of learning tasks that appeal to the abilities, interests and needs of individual learners. Today's students, who are accustomed to the "twitch-speed, multitasking, random-access, graphics-first, active, connected, fun, fantasy, quick-payoff world of their video games, MTV and Internet are bored by most of today's education" (Prensky, 2001, p. 5). Students displaying these cognitive qualities cry out for new approaches to education that fit their 21st century learning needs.

Educators must also recognize that students have a need to use their "God-imaging, creative impulse" (Perera, 2007) and that technology gives them a platform to do that. To teach the whole child and to prepare that child for kingdom work in the 21st century, teachers need to use and find appropriate technological tools that will aid in that endeavour. Technological tools must be engaged in the hands of thinking people, both teachers and students, who use those tools to achieve high standards for teaching and learning within the culture in which we live (Zemelman, Daniels, & Hyde, 2012). If it is understood that technology is part of God's good creation and that He desires the very best in any area of expertise, then educators can and must find ways to use technology in God-glorifying ways in the classrooms of today.

Purpose of the Study

Despite the abundance of literature supporting the use of technology in the classroom, and the increasing availability of online learning platforms which employ the major components of gaming characteristics, the results of most studies in gaming technology are considered too fragmented and unsystematic to produce sufficient evidence of increased learning and student engagement. Few learning technologies have managed to "cross the chasm" from adoption by technology enthusiasts and visionaries to acceptance by the vast majority of teachers. Most educators will only expend the effort needed to integrate technology into instruction when, and only when, they are convinced that there will be significant payoffs in terms of student learning outcomes (Means, 2010). To encourage change in classroom pedagogical practices and to provide concrete evidence that technology can enhance and achieve learning outcomes, more research is needed. Therefore, the purpose of this study is to determine if the use of an online mathematics learning platform in the elementary classroom, which incorporates some gaming components to create engaging, authentic, and personalized learning experiences will promote and produce a positive effect on student learning and ultimately encourage overall flourishing of the student.

Research Question

The question to be investigated is as follows:

Does student performance on a mathematics assessment differ between students using a technology-based platform and students using a non-technology-based platform?

Definition of Terms

The following definitions will be used for the purpose of this study and unless otherwise noted, are the definitions of the author.

Content area instruction – the instruction in a specific discipline, e.g. Mathematics

Digital content – this could also be known as digital media and includes most information available online, including text, audio, video, graphics, animations and images

Flourishing – the presence of psychological, social, spiritual, academic and emotional well-being

Gaming features – technology that incorporates clear goals and rules, learner control, challenging tasks, immediate feedback, repetition and the ability to move up levels of difficulty after successful mastery

Individualized learning environments – learning spaces in which students have more active control of their learning, identifying and using the study skills and learning methods that are most effective for them

Online learning platform – A method of instruction and implementation that is web-based

Number sense – an understanding of our base ten number system, including the ability to count by ones, fives, and tens, the ability to count forward and backward and the ability to recognize groups of tens and ones

Technology-based instruction – classroom instruction that incorporates the use of web-based programs and/or computer devices to advance learning

Literature Review

Consider the following: "21% of upper elementary school students have a personal smartphone, a quarter of middle school students have a personal tablet device, and more than half of high school students access the Internet outside of school via 3G/4G mobile devices" (Kiger, Herro, & Prunty, 2012, p. 61). Researchers are learning that emerging technologies such as mobile learning, online learning and digital content hold great promise for creating a new learning environment for today's 21st century student. This new learning environment not only engages students in contextually-based rich content, but also allows students to be personally involved in a learning process that empowers them to explore new knowledge with a divergent type of curiousity that is often missing from traditional classroom settings. The review of the following literature will substantiate the findings that teaching with technology will increase student achievement and overall student flourishing.

Student engagement is paramount to student success and academic achievement. In a study on student access to technology, Dosen, Gibbs, Guerrero, and McDevitt (2004) concluded that students who have school access to technology were shown to be more active, autonomous and engaged in their work. In their study of a one-to one lap top environment, Rosen and Beck-Hill (2012) confirmed that school absenteeism was reduced by 29.2% and students' discipline issues decreased by 62.5% in the experimental classes. Prensky (2005) confirmed this finding, citing that students often lack motivation and engagement within the classroom, but are totally engaged in learning outside of the classroom when they are allowed to use the technological tools that they are familiar with. Aktas, Bulut and Yuksel (2011) reported that computer-enriched learning environments, even in the mathematics classroom, make the learning more dynamic and colourful.

Classrooms that incorporate the major components of the computer games students are familiar with, such as desirable goals, interesting choices, immediate and useful feedback, and opportunities to level-up in which they can recognize their own improvement, will see an increase in student engagement and achievement. Shin et al. (2011) concluded that game technology increases positive motivation, persistence, curiosity, attention and attitude toward learning, which ultimately promotes student learning of important ideas and skills and improves student performance on algebra and mathematics problem solving. Barker (n.d), who turned her second grade classroom into a "living video game," showed a 71% improvement in reading fluency, 58% improvement in reading comprehension, and 76% improvement in Math on the Northwest Evaluation Association's Measures of Academic Progress test.

Kiger et al. (2012) maintained that mobile gaming creates an individualized learning environment in which students can choose their own learning paths, linking prior knowledge to new learning progress and thus meaningful learning. Shin et al. (2011) also discovered that technology incorporating essential game features could be an effective learning tool for students to acquire new information, depending on their prior knowledge, learning progress, learning style, preferences and needs. The research of Khan and Slavitt (2013) confirmed this:

> Giving students access to data about their progress empowers them; it helps them learn to interpret charts and develop action plans to bridge their knowledge gaps. . . . Students were not only improving their math skills, but also (were) learning to take ownership over their education. (p. 30)

To be even more specific, researchers have looked at the use of technology specifically in the elementary mathematics classroom. Most educational gaming platforms have sequences of difficulty allowing teachers to choose the entry level for students, once again meeting the needs of individual students while enabling all students to be focussing on the same mathematical strand (Reeves, 2007). Shin et al. (2011) concluded that game technology positively impacted student's learning of mathematics, regardless of students' initial ability level. They found that students who played a technology-based math game outperformed those who used a paper-based game by a 7% increase. In his study on using digital resources in the mathematics classroom, Reeves (2007) showed positive differences in student improvement between pre- and post-testing from experimental groups using technology in the elementary math classroom and the control groups who did not use technology within a six week time frame, and concluded that there is improvement in student learning in technology-enriched classrooms.

Aktas et al. (2011) reported that when using technology in the primary mathematics classroom, the computer-aided teaching had positive effects on the achievement of the students. Rosen and Beck-Hill (2012) cited similar findings in which the fourth grade experimental students significantly outperformed the control students in math scores (M = 597.6 compared with 673.9 for the experimental group and M = 611.6 compared with 660.1 for the control group) after using technology in their math classroom for one year. Kiger et al. (2102) discovered that third grade students using technology to learn and practice multiplication facts outperformed comparison students on a post-intervention multiplication test with the experimental group answering more questions correctly (M = 54.5, SD = 14.8) compared to the control group (M = 46.3, SD = 12. 5).

Researchers are learning that using technology in the math classroom allows for more student engagement and ownership of their learning, and if nothing else, adds a vibrancy to student learning. Such positive student engagement can only be viewed as an indicator of best practice in the educational world and more specifically in the elementary mathematics classroom.

Methodology

Participants

The research participants were 71 first grade students from a private Pre-K to 12 school with a Pre-K to 5 campus in British Columbia. Thirty-four of the participants are male and 37 are female with a mean age of 6. Thirty-two students made up the control group, while the remaining 39 students made up the experimental group.

Materials

A permission letter was given to all parents of students involved in the study. A pre- and post- test, created by the researcher, was used to determine mastery of mathematical concepts. Parents of the students participating in the experimental group were also given an instruction letter, explaining how to access the technology at home. An online mathematical learning platform called *Mathletics*, created by 3PLearning, allowing home and school use, was used by students in the experimental group along with regular classroom instruction. This online learning platform provided data for each individual student stating time engaged in the program and mastery of mathematical strands, specifically relating to number sense and addition and subtraction.

Design

Two of the first grade classes were used as the control group (32 students) and two classes made up the experimental group (39 students). The independent variable of this experiment was the access to *Mathletics*, the online mathematical learning platform. The dependent variable was the student achievement scores.

Procedure

During the first week of the experiment, letters were sent home with the participants in the experimental group to receive parental permission for their participation in the study (see Appendix A). Within that same week, all 71 students were given a mathematical pre-test, assessing their competency in number sense and addition and subtraction (see Appendices C and D). Individual classes were assigned randomly to one of the two assessments that were designed in advance to evaluate the same types of student learning. If Assessment A was the pre-test for a class, then Assessment B would become their post-test and vice versa.

In weeks two through seven of the experiment, two of the classes did "math as usual" in their classroom, with the classroom teacher providing all the instruction. The two classes in the experimental group were introduced to *Mathletics*, the online mathematical learning platform. During this time, a second letter was sent to the parents of the students in the experimental group, explaining the program and how to access the site at home (see Appendix B). Students in the experimental group accessed this site at school twice a week, spending 20 minutes on the site each time. The classroom teacher was there to trouble shoot any technology issues that arose, to answer questions and to clarify instructions. The classroom teacher was also available to teach concepts to individual students if the need was apparent. The researcher controlled the assignments that each student was required to complete when they signed in at school. The students needed to complete the assignments before they could participate in problem-solving math games or math fact challenges against other users. The experimental group also had access to this technology after school hours if they had access to a home computer or an iPad. The experimental group also had regular math instruction in their classroom from their classroom teacher.

In the eighth week of the experiment, all students were given a mathematical post-test to assess their competency in number sense and addition and subtraction (see Appendices C and D).

At the completion of the eight weeks, the data from the pre- and post-tests was tabulated to find the individual growth of the participants, followed by a t-test that compared the gain scores to see if there was any significant difference between the control and the experimental group with regard to academic growth. The online learning platform provided a wealth of data on the frequency of online usage, the time spent engaged in online learning, the percentage achieved relating to mastery on individual online assignments, the number of attempts to achieve mastery, the number of questions answered relating to instant recall of math facts, and the percentage achieved on test results relating to specific strands of learning. However, for the purpose of this research, not all of the data available was incorporated into this study.

Results

This study was completed to determine if student performance would differ between students using a technology-based platform in their mathematical instruction and students immersed in a typical classroom setting without having the use of technology in their mathematical instruction. To accomplish this all students were given a pre-test at the beginning of the trial to determine their mathematical competencies, specifically in the area of number sense, addition and subtraction. During the six weeks of the study, students in the experimental group were assigned to complete at least four online activities per week at school relating to curriculum. However, they could complete as many activities as they liked during after school hours. They could also make use of the component of *Mathletics* called *Live Mathletic*s, in which students could compete against class members, students across the world, or the computer itself in one-minute drills focusing on addition and subtraction.

After running the trial for six weeks, all students were given a post-test to determine if there was any growth in their learning, and whether this could be attributed to the use of technology in their instruction and practice of math skills.

In both the pre- and post-tests, the first section of the tests dealt with number sense. Students were assessed on their ability to count by ones, fives, and tens and to count forwards and backwards. They also needed to be able to show understanding of the base ten number system by recognizing the number of groups of tens and single ones in a given number, both pictorially and numerically.

All students had in-class instruction and it would be difficult to state exactly what types of instruction took place in each classroom, as that was left up to the individual classroom teacher. However, the students in the experimental group had technology-based access to activities which focused on counting forwards and backwards and counting by twos, fives and tens. They completed online activities focusing on reading numbers from words, ordering and comparing numbers to 20, describing more, less and the same and recognizing how many were in a group without having to count each individual object.

After analyzing the data, it was determined that the control group exhibited more growth than the experimental group in the area of number sense, and that the experimental group actually showed a decrease in their understanding, as outlined in Table 1.

Table 1

Number Sense: Pre- and Post-Test Scores

	Control Group Pre-Test Average	Control Group Post-Test Average	Control Group Growth	Experimental Group Pre-Test Average	Experimental Group Post-Test Average	Experimental Group Growth	Difference in Growth Between Two Groups
Number Sense	73.1%	84.4%	11.3%	90.5%	83.5%	-7.0%	-18.3%*

*P-value<0.05

This result could be attributed to a number of factors. It could be possible that because the experimental group scored relatively high on the pre-test, there was not much room for growth on the post-test and even the simplest mistakes would cause their score to decrease, skewing the overall growth scores of the experimental group. These scores may also simply be attributed to a poor testing day for the experimental group. However, without further time spent in the trial and further testing, the indisputable reasons for the decline in the experimental group's overall score in their growth of understanding of number sense will be difficult to determine.

The second section of both tests assessed the property of addition. Students needed to show understanding of addition by completing pictures, by rearranging numbers in an addition fact family and by showing how to add using a number line.

Students in the experimental group had online access to activities dealing with adding to ten, adding to twenty, adding to make five and to make ten, adding using the aid of pictures, understanding doubles and near doubles, and adding using graphs. All students had in-class instruction focusing on addition, which normally would involve the use of worksheets and manipulatives, although this was left up to the individual classroom teacher.

When tabulating the data on the addition scores, it was determined that the students in the experimental group using the online learning platform grew in their understanding by 22.2%, a difference in growth of 18.8 percentage points from the students engaged in traditional classroom learning.

Table 2

Addition: Pre- and Post-Test Scores

	Control Group Pre-Test Average	Control Group Post-Test Average	Control Group Growth	Experimental Group Pre-Test Average	Experimental Group Post-Test Average	Experimental Group Growth	Difference in Growth Between Two Groups
Addition	63.3%	66.8%	3.5%	66.6%	88.8%	22.2%	18.8%*

*P-value<0.05

This result could be attributed to the varying types of activities that students had available to them online. However, it would also be accurate to say that the students in the experimental group displayed such growth in their addition competencies because they were involved in engaging and motivating online number fact drills which would only improve their ability to compute addition equations accurately and successfully. *Figure 1* outlines the number of addition and subtraction questions answered accurately in these drills during the duration of the study. For example, one student in the experimental group completed 1,914 addition and subtraction equations successfully online over the six week trial period. It must be concluded that this would only improve that student's understanding and competency in addition and subtraction.

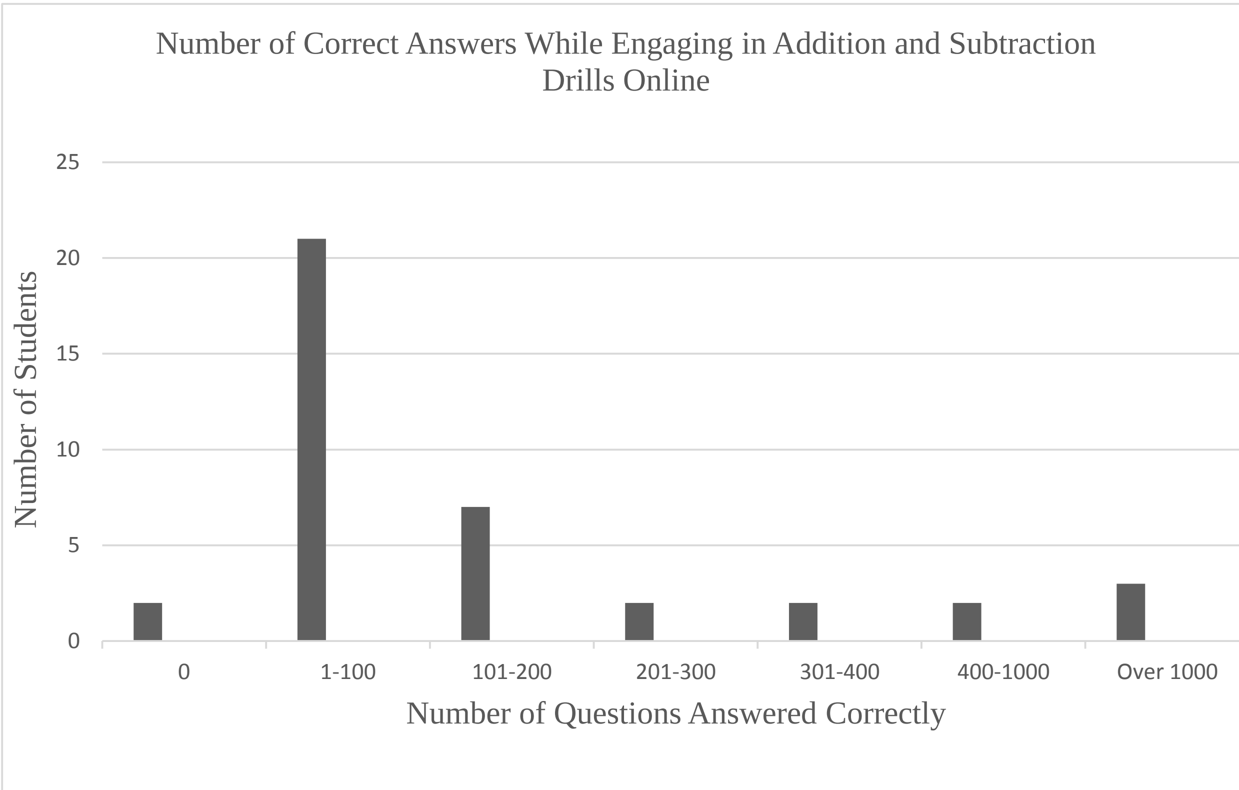

Figure 1. Bar graph showing the number of correct answers produced by students in the experimental group while engaging in drills/races on addition and subtraction.

The third section of both tests assessed the property of subtraction. Again, students needed to show understanding of subtraction by writing a number sentence to match a picture and to show how to subtract using a number line.

During the study, students in the experimental group had the opportunity to complete online activities dealing with subtraction facts to 18, subtracting from ten, subtracting using graphs and subtracting using pictures. The students in both the control and experimental groups also focused on typical math activities in their classrooms dealing with subtraction, although it would be difficult to detail the exact activities, as that was left up to the individual classroom teacher. As in the addition section, the experimental group performed considerably better than the control group of students, showing a growth of 38.7 percentage points as compared to 0.8 percentage points.

Table 3

Subtraction: Pre- and Post-Test Scores

	Control Group Pre-Test Average	Control Group Post-Test Average	Control Group Growth	Experimental Group Pre-Test Average	Experimental Group Post-Test Average	Experimental Group Growth	Difference in Growth Between Two Groups
Subtraction	58.6%	59.6%	0.8%	49.6%	88.3%	38.7%	37.9%*

*P-value<0.05

Again, this gain would most likely be attributed to the varying types of activities available to the experimental group online. To approach subtraction from many different angles would only serve to stretch and solidify their understanding of subtraction. Once again, *Live Mathletics* was also a determining factor in the substantial growth of the online learners.

The fourth section of the pre- and post-assessments determined if students understood the relationship between addition and subtraction. They were required to complete a fact family of both addition and subtraction facts using the information from a picture. Students were also required to use their knowledge of addition to find relating subtraction equations. In analyzing the data for this section (see Table 4), it was determined that the information gained was inconclusive and that there was probably not a substantial actual difference between the control group and the experimental group.

Table 4

Relationship between Addition and Subtraction: Pre- and Post-Test Scores

	Control Group Pre--Test Average	Control Group Post-Test Average	Control Group Growth	Experimental Group Pre--Test Average	Experimental Group Post-Test Average	Experimental Group Growth	Difference in Growth Between Two Groups
Relationship between Addition and Subtraction	35.0%	52.3%	17.3%	47.5%	68.7%	21.3%	3.9%*

*P-value >0.05

Table 5 details the overall growth of students in both the control and experimental groups. The data shows that students who were engaged in technology-enriched instruction showed considerably more growth (10.4 percentage points) than students engaged in more traditional types of classroom instruction.

Table 5

Overall Assessment: Pre- and Post-Test Scores

	Control Group Pre-Test Average	Control Group Post-Test Average	Control Group Growth	Experimental Group Pre-Test Average	Experimental Group Post-Test Average	Experimental Group Growth	Difference in Growth Between Two Groups
Overall Assessment	57.5%	65.8%	8.2%	63.6%	82.3%	18.7%	10.4%*

*P-value<0.05

Figure 2 also shows this information, visually representing the difference in growth between both groups of learners in each individual strand and in their overall learning.

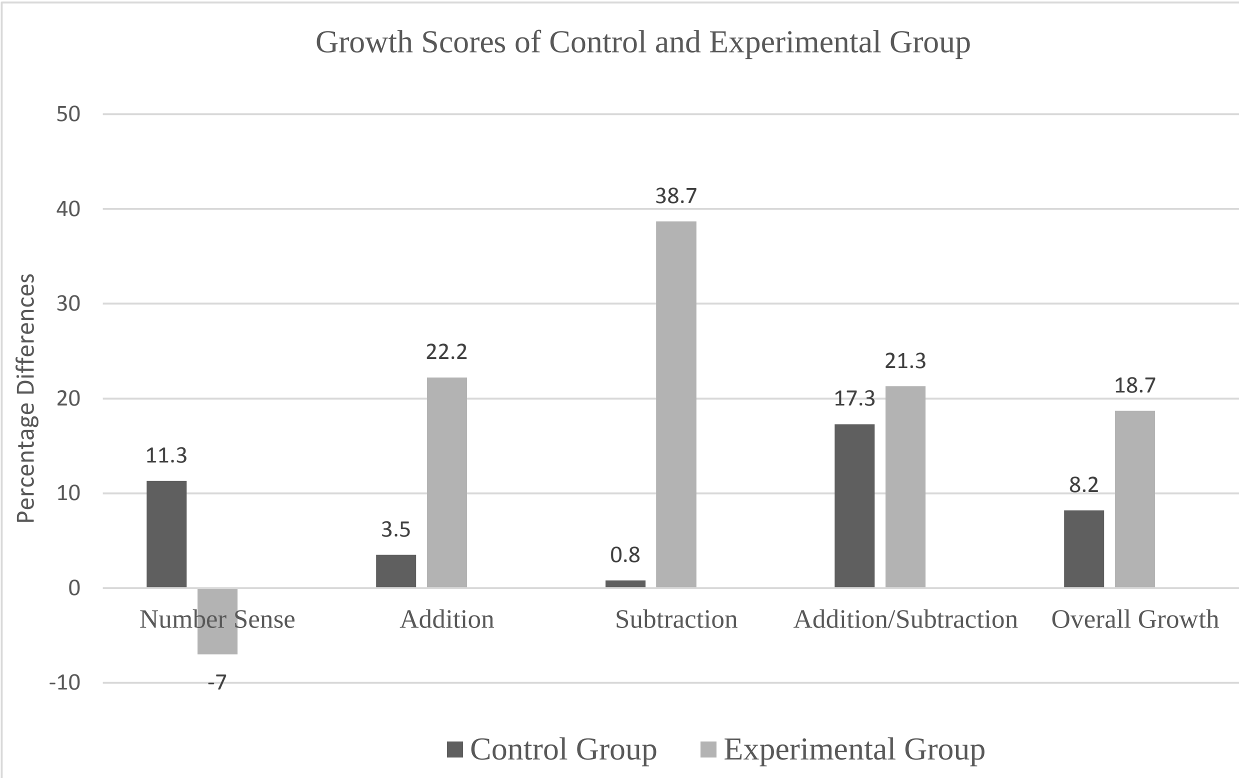

Figure 2. Bar graph showing the difference in growth in percentage scores between the control group, with regular classroom instruction, and the experimental group, using *Mathletics* as part of their Mathematics curriculum.

In analyzing the data, it must also be noted that students in the experimental group spent considerably more time than the control group each week engaged in mathematics activities, whether in curriculum activities, problem-solving games or online math fact drills in the form of competition. *Figure 3* shows the amount of time students in the experimental group spent engaged in mathematics outside of the classroom. The time spent on *Mathletics* outside of school ranged from 0 minutes to 992 minutes. It can be assumed that without the enticement of an engaging online math program, these students would not have been so deeply immersed in mathematics in their discretionary time. It can also be assumed that the time spent outside of school hours on mathematics also attributed to the substantial increased growth of the experimental group in their overall assessment.

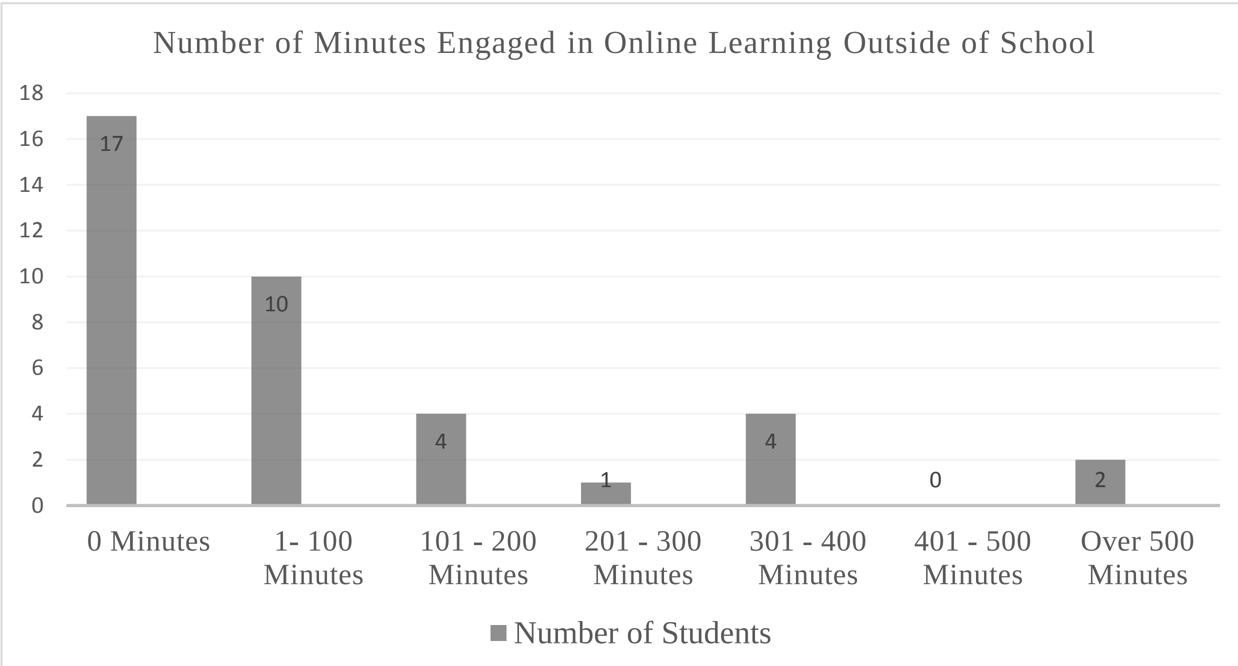

Figure 3. Bar graph showing the number of minutes spent on mathematics outside of school hours by students in the experimental group.

Discussion

Overview of the Study

The purpose of this study was to answer this question: Does student performance on a mathematics assessment differ between students using a technology-based platform and students using a non-technology-based platform? To answer this question, students from four first grade classes were involved in a trial, two classes using technology-enriched instruction as part of their math education, and two classes following a more traditional route of teacher-based instruction. All students were involved in a pre-assessment of their number sense and their understanding of addition and subtraction. After the trial of seven weeks, all students were given a post-test to determine the growth in their learning, and to determine if technology played a significant role in that growth.

Implications

The data of this action research study does not definitively prove that the use of an online learning platform will improve students' scores on assessment tools. In both the experimental and control groups, students improved in their overall mathematical learning. However, students using *Mathletics* did exhibit considerably more growth in their addition and subtraction competencies and a noticeable growth in their understanding of the relationship between addition and subtraction. This could be attributed to their opportunity to engage in the online gaming aspects of *Mathletics*, in which students had the opportunity to take ownership of their own learning by choosing engaging activities and having the ability to move up levels as mastery was achieved. It could also be attributed to the opportunity students had to race fellow classmates, students in other countries, or the computer in math fact drill activities, gauging their success while continually trying to improve in speed and accuracy.

Although it is the goal of any teacher to have their students attain proficiency in any given subject, the opportunity for engaging and meaningful learning must also be addressed, and it is in this area that technology-based learning has the potential to enrich and expand traditional classroom learning. When using *Mathletics*, the students in the experimental group had the opportunity to take ownership of their own learning. They could earn points towards certificates by completing activities to mastery of 85% or higher, and students could attempt these activities as many times as it took to achieve mastery. When concepts were difficult, students had the opportunity to listen to an online animated tutor explain how to go about a problem. The program had enough variety that students could choose curriculum-related activities, problem-solving activities that were in the form of games, and speed and accuracy drills at their level in the form of timed races. All of this had students immersed in Mathematics, working at their own level, having the advantage of instant feedback and the opportunity to re-do an activity, while working on a platform that remains a part of their everyday life – the world of technology.

Although the online learning platform was advantageous for students, it also had excellent components for teachers. As in *Mathletics*, Khan Academy advocates also found that online learning platforms are not only valuable to students, but to teachers as well. Thordarson, (as cited in Schaffhauser, 2013) stated:

> The value of Khan lies with its lesser-known components: open-ended and interactive math exercises and the data those produce. "Khan Academy for us is a tool that helps us drive curriculum decisions. It generates data unlike any other tool that we've got. I can get immediate feedback on how kids are performing on certain skills that I can't get from other assessments. It's real time." (p. 23)

The first grade teachers in this trial also had this real-time advantage. By accessing the teacher portal, they could instantly see what each student had mastered and how many attempts it took for mastery, how many addition and subtraction questions they had answered correctly and the average time they took for each question in those drills. They could make plans for further instruction, knowing the understandings and capabilities of each student.

However, educators must also be warned that technology is not a replacement for the interpersonal contact that a teacher can give. The teacher must remain at the heart of the classroom and as the designer of curriculum. Thordarson, (as cited in Schaffhauser, 2013) stated, "You have all of these resources . . . and based on the needs of your students, you are picking and choosing what works for you in that moment" (p. 24). Teachers must still actively teach, only using technology when it is appropriate for increased student learning. They must continually be informing their own practice by asking the questions, “Will students be pushed to higher levels of thinking or achievement? Is it a gimmick that will be abandoned when the novelty wears off? Is this the next appropriate step?” (Hamilton, 2007, p. 11).

Schaffhauser (2013) also warned that technology-based learning platforms, especially in the area of primary mathematics, still find it difficult to incorporate authentic problem-solving activities. “You only learn to problem-solve when you’re working on something you don’t already know how to do” (p.21). In the primary classroom, this also serves as a reminder that the computer and technology cannot take the place of real life objects and manipulatives; young children must still be given opportunities to develop an understanding that number and counting are not just symbols on a page or a screen.

If the use of technology in the elementary math classroom increases student engagement and produces improved student achievement in the acquisition of knowledge, it would only stand to reason that using technology can be viewed as an educational tool to aid in the ultimate flourishing of every student. Dosen et al. (2004) specifically stated that:

> If religious schooling is to prepare students to be good and effective citizens in the twenty-first century, it is imperative that sectarian schools provide their students with opportunities to make wide use of technology. . . . It would be impossible for students to function effectively in the world without the ability to not only use computer technology, but to be able to evaluate the effectiveness of the data that they receive by using this technology. (p. 290)

According to Prensky (2005), schools should be teaching students how to “program, filter knowledge, and maximize the features and connectivity of their tools” (p. 10), or in more colloquial terms, to flourish in the world in which they live and learn.

Before the study, students’ previous exposure to mathematics instruction was almost solely in the classroom through very traditional methods. Through the use of technology-enriched instruction, these students were introduced to a whole new world, available at their fingertips. They could, and did, spend hours on building their competency in Math outside of the classroom. They could choose activities in the order and at the difficulty level in which they felt comfortable, taking ownership of their own learning. Students could see their own improvement and celebrate their immediate success because the data was available to them instantly on the screen. Because of technology, students were flourishing as rational, creative beings in a world, which up to that point in their education, had been highly prescribed and inhibitive. This would seem to corroborate that technology not only supports the flourishing of students, but also provides Christian teachers with the tools to differentiate instruction for each student to best address their individual needs and to best encourage the gifts and abilities of each learner in their classroom.

Recommendations

The data obtained from the pre- and post-assessments of both the experimental and control group shows growth of learning in both groups of learners; however the experimental group showed an overall increase of 10.4% over the control group. Because of that data, this researcher recommends that technology be used as one component of a blended method of instruction in the elementary mathematics classroom. Students involved in the trial definitely made use of the opportunity to use the technology outside of school, and therefore were meaningfully engaged in mathematical learning for a larger part of their day. The students in the experimental group could also take more ownership of their learning online while still receiving the instruction of their classroom teacher when necessary. Using the online learning platform was also advantageous for teachers, giving them a wealth of data on which to inform their continued instruction and in which to meet the current needs of their students.

Limitations of the Study

While there was great care taken to ensure the accuracy of the findings of this action research, there were several factors that could have affected the conclusions drawn in this research. A major factor limiting the findings of the study relates to the view of technology held by the families of the students in the experimental group. In some homes, children were not allowed to use the family computer and thus were not allowed to make use of *Mathletics* at home, which limited their use of the technology and their opportunity to benefit from it. In other homes, students "screen time" was closely monitored, which put students at a disadvantage to use the program to its highest potential.

The quality of testing may have been an issue. Although both tests were designed to assess the same types of learning, the types of questions did differ slightly between tests and might have confused some children. The time of the final assessment was also an issue, as the post-test was given one week before Spring Break, a time in which students are generally tired and not ultimately at their best. This was also a time when other assessments were being completed to gain data for report cards and students may have been suffering from assessment exhaustion. It should also be noted that Canadian students, especially at the primary level are not at all used to any forms of standardized testing. For some students it was a challenge just to complete the test once. Having to take the post-assessment seven weeks later was overwhelming for some, as was evidenced by more sections or questions left incomplete than in the pre-test.

At the primary level, the length of the study was definitely a limitation to the accuracy of the findings. Students at such a young age need almost four weeks to become comfortable with an online learning platform, and that was definitely the case in this study. It took that long for many students and families to realize that the technology was available to them at home, and then longer still to utilize all the different aspects of the program. To truly judge the efficacy of the technology-based learning, the research would have to be done for a minimum of three months with preferably a six month trial. During this type of trial, students would be given several assessments to judge their progress in learning and then a final assessment to evaluate their final progress.

A final determining factor as to the legitimacy of the study could also be the expertise of the four classroom teachers and the learning environments they have created. All four teachers have varied amounts of experience ranging from two to over 20 years of experience. Their individual classroom environments also vary greatly, with some instruction being very systematic and structured whereas other instruction was of a more open-ended nature. These two factors would definitely influence the type of in-class mathematical instruction that was available to students.

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Appendix A

Parent Permission Letter

Dear Grade One Parents:

Although your child is in grade one and their small school world revolves around their classroom teacher and their friends, he/she may know who I am. However, let me formally introduce myself. My name is Judy de Waal, and I teach one of the Upper Primary classes at Abbotsford Christian. In addition to that role, I am also a student in active pursuit of my Masters degree in Curriculum and Instruction. I am nearing the completion of my studies, with one final project to complete.

During this term, I will be engaging in my Masters Thesis which I have entitled, *"Technology, Mathematics and the Flourishing of the Elementary Student."* As I was researching this topic, I realized that our school environment was set up perfectly this year to help me in my research. As we have four grade one classes, I have been given permission by our school administration to use two grade one classes as the control group for my study and to have two classes make up my "experimental group."

Your child's class was chosen to be a part of the experimental group, and as such they will be using technology in their weekly math learning for the next six weeks. Our school already uses an online math program in the upper grades, and for the duration of the study, your child will also have access to this program. In all four classes, math instruction will continue as normal; however, in the experimental group the teachers will also include online learning as part of their methodology. It will be my task at the end of the study to interpret if young children benefit from using technology in their learning, and if it adds to their growth as individuals and as positive learners. Our school mission statement refers to engaging minds, nurturing hearts, and creating world-shapers and I am eager to see if the use of technology, especially at such a young age, will already help us to live out that mission statement.

I am excited to be on this completion leg of my Masters journey, but to continue, I do need your permission to have your child participate in my study. Could you please sign the permission slip below and return it to school by the end of this week? That would be greatly appreciated.

If you have any questions, please stop by to chat or send me an email at jdewaal@abbotsfordchristian.com.

JUDY DE WAAL
Elementary Teacher
Phone: 604.755.1891 x1106
Web: abbotsfordchristian.com

ABBOTSFORD CHRISTIAN SCHOOL
Engaging minds. Nurturing hearts. Shaping God's world.

✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂✂

I give permission for my child ________________________ to participate in the experimental group in the study "*Technology, Mathematics and the Flourishing of the Elementary Student.*"

______________________________ ______________________________

(Printed Name) (Signature)

Date: ____________________________

Appendix B

Parent Instruction Letter

Dear Grade One Parents:

We have jumped into this study with both feet. As part of the experimental group in my study, your child has had their first experience with *Mathletics*, our school online math program and they are excited to continue that experience at home. We spent time in the lab today, creating our avatar and just becoming familiar with how *Mathletics* works. With their unique username and password, your child will have 24 hour access to *Mathletics*. This means that your child can work at their own pace; anytime and anywhere. Each student's *Mathletics* account holds information relating to individual results and progress. This means that it is highly important that only your child uses their password.

About *Mathletics:* *Mathletics* is a web-based learning program that integrates home and school learning via the internet.

***Mathletics* at Home:** I recommend that you spend time looking at the program with your child so that you can gain the greatest understanding of how *Mathletics* will benefit his/her learning. As a parent, you can sign up to receive weekly reports. These reports will provide you with details on your child's progress and achievements.

To register for this service:

- Visit www.mathletics.ca/parents
- Complete the fields and click submit.
- Record your new username and password.

Your child's username and password is attached to this sheet. If you misplace it, just email me at jdewaal@abbotsfordchristian and I will be happy to refresh your memory.

To access the Parent Center:

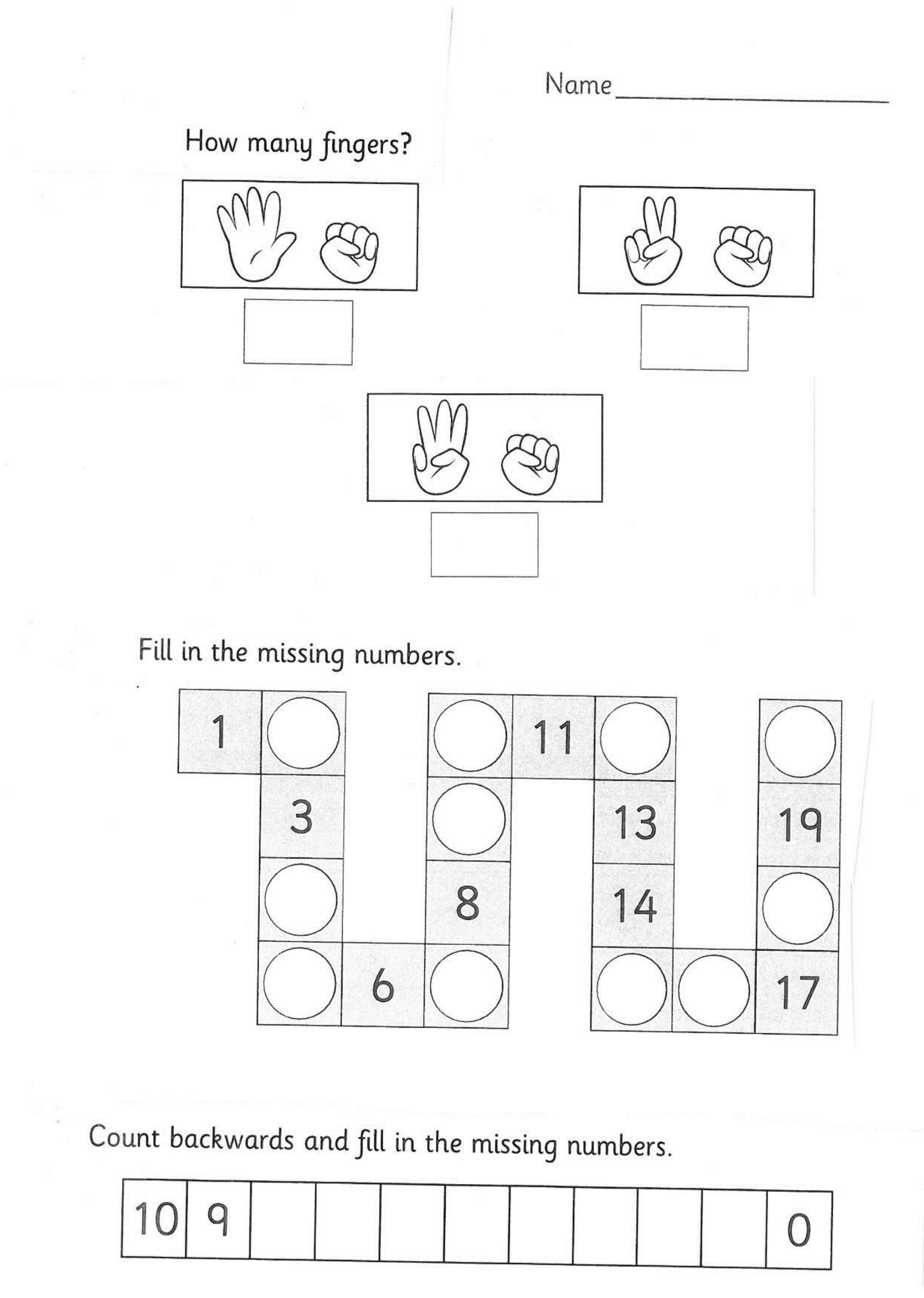
- Visit www.mathletics.ca
- Sign in using your own user details

Further information and guides on *Mathletics* can be found under the Help tab. If you experience difficulty in loading the *Mathletics* website at home, please contact them at 1-877-467-6851 or at customerservice@3plearning.ca.

Thanks again for participating in this,
Judy de Waal

Appendix C

Assessment A


Name ____________________

How many fingers?

Fill in the missing numbers.

1 3 6 8 11 13 14 17 19

Count backwards and fill in the missing numbers.

10	9									0

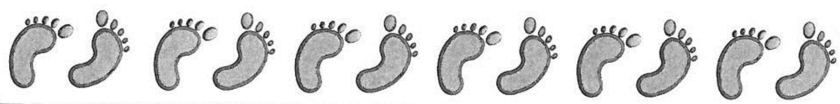
Write the numbers that come before and after.

		8		

What numbers come next?

25	26	27					

Count by 5s to find how many toes.



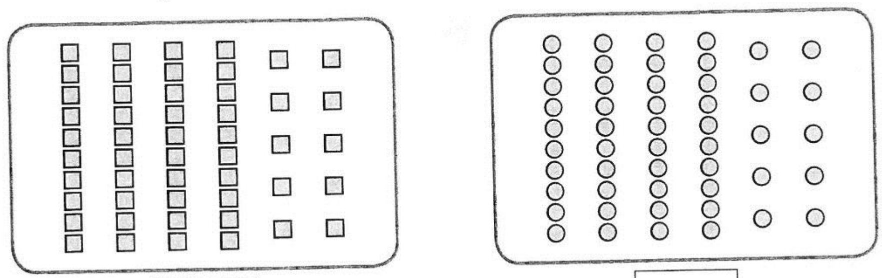
There are ☐ toes.

Finish the counting by 10s patterns.

17	27	37			

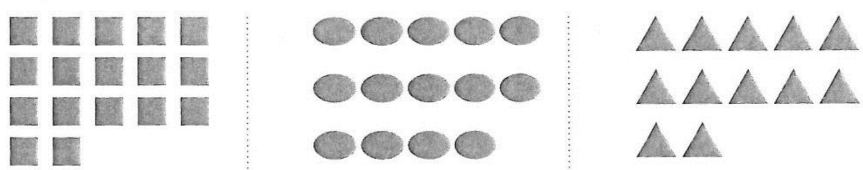
11	21	31			

Circle the shapes to match the number.



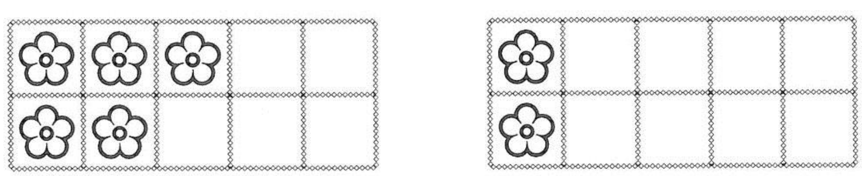
31 49

Circle the groups of ten. Write how many tens and how many ones.



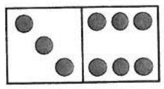
__ ten __ ones | __ ten __ ones | __ ten __ ones

Draw the extra flowers. Complete the number facts.



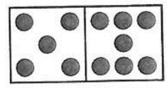
$5 + \mathbf{4} = \square$ $2 + \mathbf{3} = \square$

Use turnarounds to solve these. Write both number facts.



$3 + 6 = \square$

$\square + \square = \square$

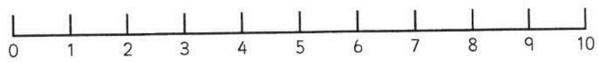


$5 + 7 = \square$

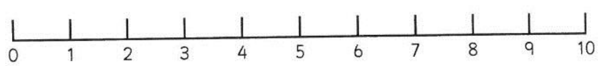
$\square + \square = \square$

Hop along the number line and finish the number fact.

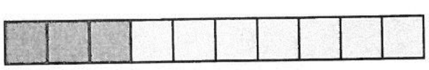
$5 + 3 = \square$



$8 + 2 = \square$



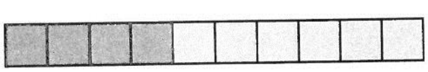
Finish the addition fact. Can you find 2 matching subtraction facts?



$3 + \boxed{7} = \square$

$\boxed{10} - \square = \square$

$\boxed{10} - \square = \square$

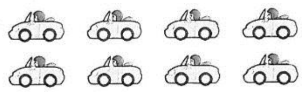


$4 + \square = \square$

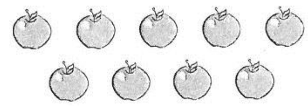
$\square - \square = \square$

$\square - \square = \square$

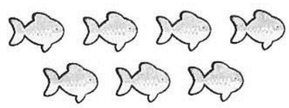
Cross out pictures to match these number facts.



8 – 4 = 4



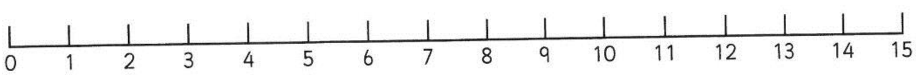
9 – 3 = 6



7 – 3 = 4

5 – 2 = 3

Complete these subtraction facts. You can use the number line to help you.



15 – 10 = $\square$

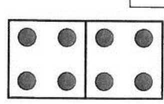
14 – 3 = $\square$

15 – 5 = $\square$

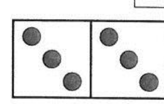
13 – 3 = $\square$

Use your doubles facts to help solve these subtraction problems.

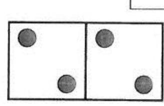
8 – 4 = $\square$



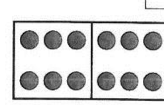
6 – 3 = $\square$



4 – 2 = $\square$



12 – 6 = $\square$

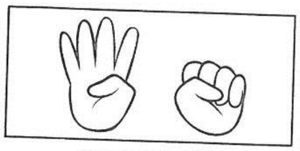


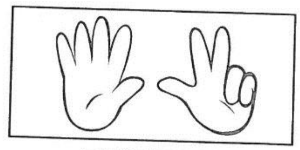
Appendix D

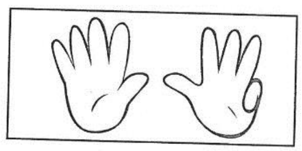
Assessment B

Name ____________________

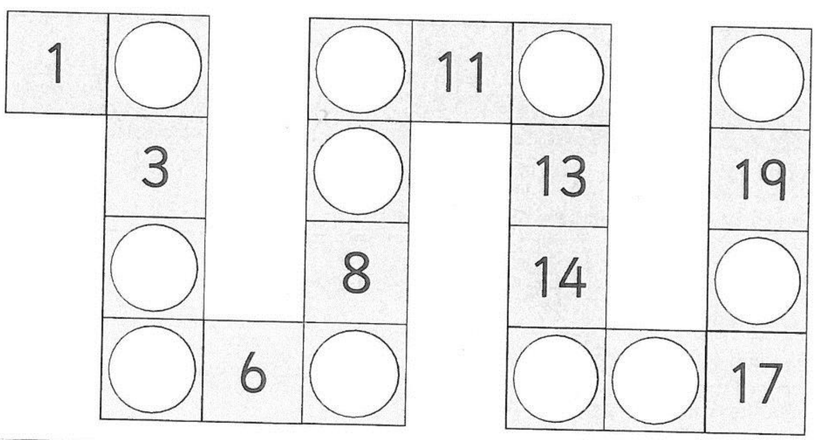
How many fingers?







Fill in the missing numbers.



Count backwards and fill in the missing numbers.

20										10

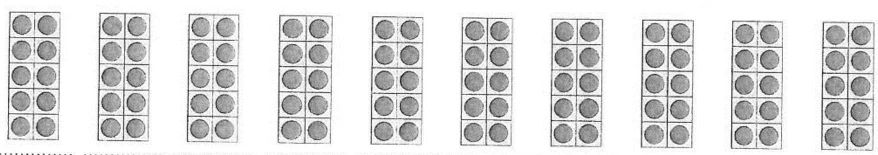
Write the numbers that come before and after.

		15		

What numbers come next?

36	37						

Count by 10s to find how many.

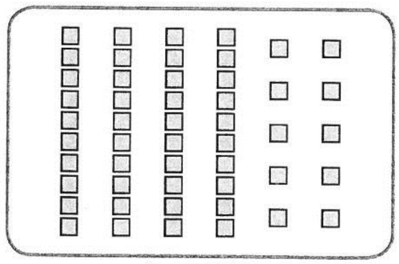


10	20				60				

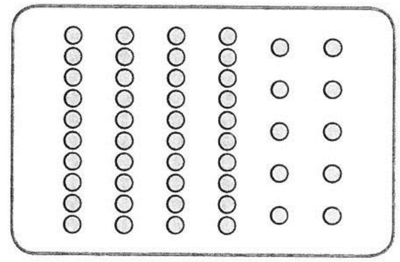
Fill in the missing numbers.

1		3		5		7		9	
11		13		15		17		19	
21		23		25		27		29	

Circle the shapes to match the number.

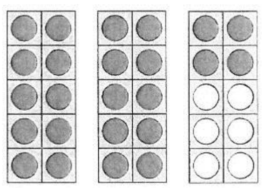


40



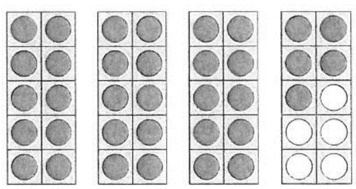
25

Circle the full groups of tens. Write how many tens and how many ones. Then write the number.



tens	ones

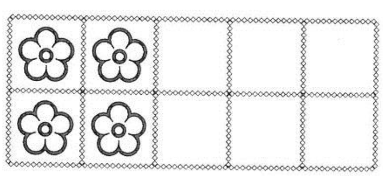
______



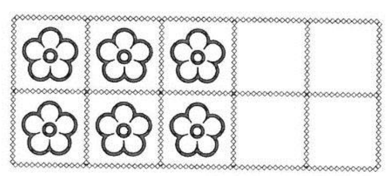
tens	ones

______

Draw the extra flowers. Complete the number facts.

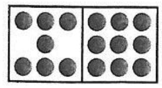


$4 + 1 = \boxed{}$



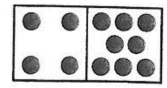
$6 + 2 = \boxed{}$

Use turnarounds to solve these. Write both number facts.



7 + 9 = □

□ + □ = □

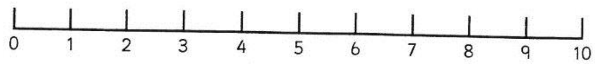


4 + 8 = □

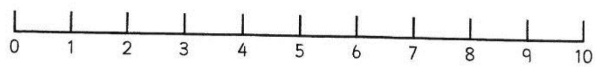
□ + □ = □

Hop along the number line and finish the number fact.

3 + 4 = □



5 + 3 = □

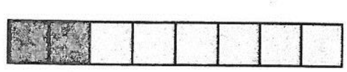


Finish the addition fact. Can you find 2 matching subtraction facts?

5 + □ = □

□ – □ = □

□ – □ = □

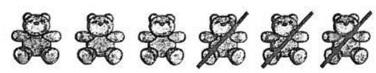


2 + □ = □

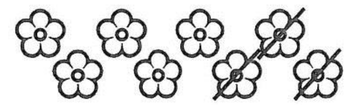
□ – □ = □

□ – □ = □

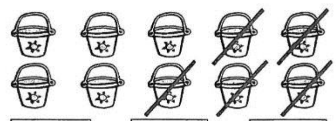
Show these picture stories as number facts.



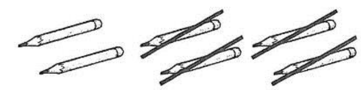
☐ – ☐ = ☐



☐ – ☐ = ☐

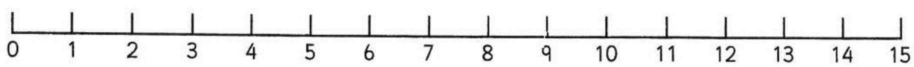


☐ – ☐ = ☐



☐ – ☐ = ☐

Complete these subtraction facts. You can use the number line to help you.



12 – 5 = ☐ 15 – 8 = ☐

11 – 7 = ☐ 15 – 2 = ☐

Finish and match the addition and subtraction doubles number facts.

2 + 2 = ☐ 6 – 3 = ☐

5 + 5 = ☐ 8 – 4 = ☐

4 + 4 = ☐ 10 – 5 = ☐

3 + 3 = ☐ 4 – 2 = ☐