The Effect of a Technology-Based Program on the Retention of Mathematics Skills

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Abstract

The purpose of this study was to determine whether a Technology-Based Intervention Program, Study Island, would positively affect the skill retention of mathematics skills of eight selected third grade special education students. The measurement tool was the Baltimore County Public Schools (BCPS) unit assessment for the geometry unit. This study involved the use of a pretest/posttest design to compare data from March of 2013 (before the intervention was administered) to data from June of 2013 (after the intervention was complete). The results of the study show a decline in students' skill retention, but the amount of the decline was not statistically significant, thus could have occurred by chance. Research in the area of Technology-Based Intervention programs should continue in order to determine the reliability and validity of these types of programs.

CHAPTER I

OVERVIEW

This study was designed to determine the effect that technology-based programs have on skill retention of previously taught mathematics skills for special education students.

The researcher, who teaches mathematics to special education students in a small group classroom setting, has frequently observed that students have difficulty retaining skills learned in previously taught math units or in previous years of schooling. Students seem to do well on unit exams given directly after the units are taught; however, they do not seem to retain the skills for use during daily assessments, benchmark assessments, or during classroom instruction. This situation often occurs after students are unexposed to the skill for an extended period of time. Lack of knowledge in the previously taught skills makes it difficult for students to extend the skills or to use them to acquire new concepts. Consequently, students' scores on pre-assessments and benchmark assessments do not show student growth because they are often unable to access previously taught skills for exploration or to show skill acquisition. Lack of prior knowledge causes these students to struggle with new material or more complex mathematics.

When researching ways to increase or acquire skills, the researcher referenced The Encyclopedia of Cognitive Science. According to Skill Learning (2005), practice of learned skills can increase the retention of the skill if the practice is focused on the abstract aspects of the skill so that knowledge of the skill can be applied to new situations. Through this type of practice the ability to execute a skill with little or no effort continually increases until it reaches the point of automaticity. Based on these findings, it is clear that continued or incremental rehearsal, when focused on the abstract aspects of the concept, may lead to increases in skill retention among students. If more time is devoted to continued practice of learned skills students may be able to execute learned skills with more automaticity and retain the skills over a period of non-use.

Studies illustrate methods of incremental rehearsal that may allow for increases in student retention. When determining ways to implement incremental rehearsal with students, the researcher found that students are highly motivated by technology-based programs. Particularly motivating are technology-based programs which allow for this type of incremental rehearsal to take place in a game mode. Hoffman and Nadelson (2010) acknowledge that the use of technology-based games that directly correlate to instruction may allow for instructional expectations to be met. This claim supports the idea that technology-based programs that use games to deliver, review, and reteach skills can lead to attainment of the desired content and serve as a valuable intervention tool for students who are having difficulty retaining learned skills.

Statement of the Problem

The purpose of this study was to determine the effect a technology based program, *Study Island*, had on the skill retention of selected mathematics skills among special education students.

Null Hypothesis

Students in the 3rd grade experimental group will show no statistically significant difference in the level of skill retention of previously taught math skills after using a technology-based program for incremental rehearsal.

Operational Definitions

For the purpose of this study, level of skill retention is defined as each student's pre-assessment score on a geometry unit test (pre-assessment) which was administered to students after completion of the unit through classroom instruction and post-assessment score administered approximately three months later.

Also for the purpose of this study, a technology based program called *Study Island* which allows students to incrementally rehearse, review, and master skills was used.

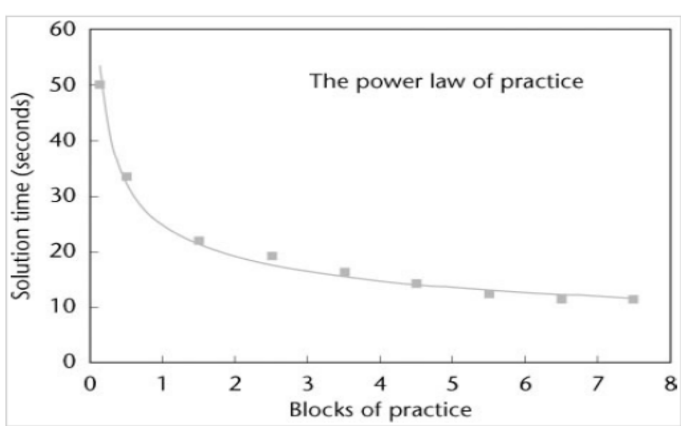
CHAPTER II

A REVIEW OF THE LITERATURE

This literature review seeks to explore the topic of poor skill retention in mathematics at the intermediate elementary school level. Section one provides an overview of skill retention and how skills are acquired. Section two discusses why students are having difficulty retaining skills. In section three intervention strategies for improving skill retention are discussed.

Skill Retention

According to the Encyclopedia of Cognitive Science (2005), a skill is "an acquired ability that has improved as a consequence of practice" (Skill Learning, 2005, Introduction, para. 1). Thus, skill learning, or skill acquisition is improvement through practice or continually conducting the same activity. Research has shown that as skills are learned, the speed of performance for those skills increases. The rate at which speed of performance increases remains similar across a wide range of mental and physical skills; as skills are acquired, excelerated performances are observed in the first few attempts at demonstrating the skill and increases in speed get increasingly smaller as additional attempts are made. Figure 1 indicates that greater improvement is made early in practice rather than late in practice.



Time required to solve multiple-step arithmetic problems as a function of practice. A power function curve is fitted to the data. (Figure 1.)

As practice continues, reorganization of the activity begins in order for superior performance of the skill to be demonstrated. Through the use of restructuring, steps necessary in novice stages of skill acquisition are eliminated. This type of restructuring is seen in the acquisition of simple arithmetic skills such as addition. When children begin learning addition, they often learn tedious and inefficient counting procedures. Once restructuring occurs and children acquire perceptual chunks of the concept, they begin using more direct single - step methods in solving addition facts (Skill Learning, 2005). Through practice the ability to execute a skill with little or no effort continually increases until it reaches the point of automaticity. Learning essential skills, such as automatic retrieval of arithmetic facts, becomes critical to the acquisition of more complex skills.

Retention of skills can often be predicted from practice performance because retention of well-learned skills through the use of practice is often high. Therefore, according to Skill Learning, (2005), "larger amounts of practice may increase retention," (Retention and Transfer sect. para. 1). While larger amounts of practice may increase retention, the specificity of the practice is important in skill retention as well. "When the conditions for performing a skill are changed only slightly, the benefits of practice may be lost or dramatically reduced" (Retention and Transfer sect. para. 2). Because specificity of practice can place limits on the transfer of skill knowledge, the type of practice needs to be focused on the abstract aspects of a skill so that skill knowledge can be applied to new situations.

Stages of Skill Learning

During the initial stage of skill learning, the directed stage, instruction is needed, usually an external source, for the skill to begin to be acquired. Lack of knowledge of the skill and a lack of working memory of the skill limit the initial performance of the skill. This stage of skill learning may extend for different periods of time depending on the particular skill being acquired. The intermediate stage of skill learning is a period in which the skill is restructured, strategies are increasingly refined, and initial steps are skipped as performance becomes more proficient. The final stage of skill learning is often referred to as the routine stage of skill learning. In this stage an already well-known skill is continually improved through small increments in performance fluency (Skill Learning, 2005).

Difficulties with Skill Retention

Within the concepts of skill retention, there are several problems. These difficulties include the lack of prior learning, mathematical learning deficiencies, and student behavior.

<u>Lack of Prior Knowledge</u>

Ray and Smith (2010) believe that receiving a solid academic foundation in kindergarten is essential to assure future academic success. Educators can agree that this academic foundation is a stepping stone for future endeavors. Memory capacity directly effects students' ability to activate prior knowledge in order for prior knowledge to be applied to new learning. Kindergarten serves as a time for children to learn organization tasks that allow them to engage in repeated practice. Repeated practice is a common teaching practice that provides kindergarten students with a positive start to their school careers. Research has shown that children's mathematical abilities in kindergarten are predictors of future mathematical ability. The development of number sense and fluency of basic math computation lead to higher levels of achievement in math skills.

According to the National Council of Teachers of Mathematics "the foundation for children's mathematical development is established in the earliest years" (as cited in Development of Young…, 2006, p.1). The National Association for the Education of Young

Children (NAEYC) believes that “high-quality, developmentally appropriate mathematics education for children age three to six is vital” (as cited in Development of Young…, 2006, p.1). Public schools in the United States do not foster this type of mathematical development, and early childhood mathematics instruction is overlooked even though preschoolers and kindergarten students are able to construct informal mathematic knowledge necessary for later success with formal mathematics. Building prior knowledge in kindergarten is critical to future math success. Number sense and computation fluency are critical, or students will struggle with future math skills (as cited in Development of Young…, 2006).

Effects of Mathematical Learning Disabilities

Miller and Hudson (2007) contend that mathematics is the most difficult content area for students with learning disabilities. Research has shown that students with learning disabilities are performing significantly below grade and make little progress with computation skills from one year to the next. Students with learning disabilities often struggle due to memory deficits, inability to attend to specific aspects of a task, and a lack of motivation to complete tasks. These characteristics make current classroom reforms in mathematics difficult for students with learning disabilities to flourish. Emphasis on problem solving and student-centered instructional practices which have made the curriculum activities and cognitive demands too high for students with learning disabilities. Students with learning disabilities can benefit most and develop mathematics competence through the use of explicit instruction and evidence based practices. Students with mathematical learning disabilities have difficulty with central executive processes necessary in problem solving skills, which are highly emphasized within current curricula. Mathematical learning disabilities make it difficult to decipher between relevant and irrelevant information when problem solving in mathematics (Passolunghi & Mammarella, 2012).

Students with mathematical learning disabilities also have difficulty with controlled attention, which makes more complex span tasks difficult. Visual working memory tasks are areas of strength for students with mathematical learning disabilities; therefore, students should be trained in creating spatial representation of arithmetic problems to increase their problem solving abilities.

Engagement and Behavior Difficulties

"Students with emotional and behavioral disorders (EBD) demonstrate significant deficits across content areas" (Vostal, 2012, p. 3). Research shows that students with EBD often have difficulty with mathematics and that math achievement declines as years of schooling increases. Students with EBD generally lack basic computation skills necessary to complete higher-level math tasks. Lack of computational skills is directly associated with lack of engagement in practices which develop these basic skills. Motivation is a key component for practice to occur and the intent of the motivation, practicing with a purpose, is critical for improvement in performance (Skill Learning, 2005). Because students with EBD often choose not to engage in academic tasks due to their negative beliefs about their academic abilities, they continue to fall farther behind academically. The disruptive behaviors that they demonstrate during classroom instruction make it difficult for instruction to occur and in turn lead to losses in academic achievements.

Lack of Incremental Rehearsal

Incremental rehearsal, or drilled rehearsal, has consistently been shown through research to be an effective method to increase retention of basic mathematical skills. Research has shown that increased retention of basic mathematical skills has increased performance on higher level mathematics skills (Burns, 2005). Lack of incremental rehearsal has made it difficult for students to master basic mathematics skills necessary for skill retention of higher level mathematics (Codding, Archer, & Connell, 2010). When practice is done over multiple occasions and spread out over an extended period of time, rate of skill retention increases; whereas if practice is massed and done in a relatively short period of time skill retention decreases (Skill Learning, 2005). According to the NCTM, fluent computation is a goal for mathematics instruction but is an area of weakness for many students - especially students with mathematics learning disabilities (as cited in Development of Young…,2006). When a student is able to recall mathematical facts with automaticity, they are considered to be fluent. Through the use of incremental rehearsal, increases in this type of automaticity can be seen. The National Mathematics Advisory Panel (2008), relates lack of basic skill fluency to the quantity and quality of the practice being conducted in classrooms. They attribute this lack of quantity and quality of practice to insufficient curricula activities which foster fluent performance and to the lack of teacher emphasis and time allotment for necessary incremental practice to take place.

Interventions

There are several types of interventions that appear to be successful when used consistently with students.

Tutoring and Peer Tutoring

Tutoring, as defined in Tutoring, (2007), is a method of instruction in which one student or a small group of students receive personalized and individualized education from a coach or instructor. Research has shown that this type of intervention has been very successful when it is organized, structured and there is a positive relationship between the tutor and tutee. Tutoring is most often used in addition to regular classroom instruction to remediate or supplement the classroom learning. Guidelines in developing a successful tutoring program should be used in order to ensure that the tutoring program will be successful. Consistency of the program is a key component to the program's success. Research has shown that consistent programs held at least twice a week for a minimum of ten weeks are most successful. The tutors should also be carefully selected based on knowledge of the topic to be taught, dependability and responsibility of the potential tutor.

Research has also shown that peer tutoring has been an effective way to improve academics of children with disabilities (Peer Tutoring, 2007). Success of peer tutoring programs is based on similar characteristics to tutoring programs. Preparing peer tutors with techniques for tutoring is critical to the success of the program. Teachers must invest energy into creating, implementing, and assessing the success of the peer instructional meetings. There are two types of peer tutoring programs. Peer tutoring is used to define a tutoring program which involves a tutor of the same age, with higher academic abilities, tutoring a student achieving at a lower academic level. Cross – age tutoring is another type of peer tutoring in which students, several years older, tutor students several years younger (Tutoring, 2007). While peer – tutoring can be implemented in many different ways, research has shown benefits for both the tutor and tutee. Students who participate in peer – tutoring programs, as a tutor or a tutee, have been known to make significant improvements academically, socially, and intrinsically.

Teacher Professional Development

Teacher effectiveness is a key component in the success of students. Being an excellent teacher first requires a teacher to be an effective teacher (Teaching Effectiveness, 2004). Effective teachers possess specific qualities such as subject knowledge, availability, organization, and enthusiasm; however, excellent teachers place emphasis on outcomes which show increased student content knowledge that allows students to think independently and regulate their own learning. Excellent teachers ensure that the teaching strategies and approaches they are using align with the students' approaches to learning so that high quality outcomes can consistently be achieved.

Because teacher effectiveness is a key component in student academic achievement, it is essential for teachers to continually participate in professional developments which can help them to foster high – quality outcomes. As changes in curricula and teaching approaches occur, teachers must engage in continuing professional development to remain effective (Continuing Professional Development…, 2007). Research has noted that professional development not specifically directed at participants is ineffective because it is deemed irrelevant and participants are not transferring the knowledge from the professional development to their own classroom setting. Research has indicated that school - based professional developments have been deemed more successful because specificity of the professional development can be geared towards specific teacher needs and can be implemented by participants in their own classroom settings. Teacher professional development is a critical intervention piece for students who struggle to retain learned skills because the most effective and excellent teachers are constantly learning new strategies and approaches to gaining high – quality outcomes from students.

Technology - Based Programs

"Teachers can foster and assess student learning creatively through technology based educational games" (Salend, 2009, p. 51). Teachers can use technology – based programs to monitor student progress, both formally and informally, and make decisions, based on this program monitoring, on ways to improve students' instructional programs. Technology- based programs are an easy, efficient way for teachers to monitor student learning and intervention effectiveness. Curriculum-based measurements are often taken by teachers over extended periods of time. The use of technology can allow teachers to implement curriculum based measurements efficiently and gather individual or class data to be analyzed for further instructional implications (Salend, 2009).

Hoffman and Nadelson, (2009) found that video game players who believe that a goal is attainable will intensify their efforts in task completion because the value of the goal is elevated. These researchers also found that video game players were resourceful, persistent, and goal-oriented. These findings support the use of technology-based programs that use games to review, revisit, and reinforce previously taught skills for the intention of retaining skills due to the increases in engagement and motivation associated with video gaming. While Hoffman and Nadelson acknowledge that their findings show that video gaming did not increase instructional expectations, they do state that instructional expectations can be fulfilled if there is a direct relationship between the game and the learning content that is desired. This claim supports the idea that technology-based programs that use games to deliver, review, and re-teach skills can lead to attainment of the desired content and serve as a valuable intervention tool for students who are having difficulty retaining learned skills.

Summary

In conclusion, several important implications have been noted to explain difficulties with skill retention. Students are often lacking the prior knowledge that is necessary for success in later mathematical concepts because of the lack of incremental rehearsal. Many students have difficulties with skill learning because of mathematical disabilities that inhibit their learning; other students struggle because of lack of motivation or behavioral issues. Despite all of these obstacles faced by educators today, interventions may help to alleviate or strengthen skills. Educators first need to be trained in effective teaching strategies that are applicable to their current teaching positions and should work towards becoming excellent teachers by implementing best practices learned through continuing professional development. Secondly, programs such as tutoring or peer tutoring should be implemented to help reinforce and supplement skills students are learning in the classroom. Lastly, the use of technology can play a vital role in skill retention and development and should be considered when determining intervention strategies to help students retain or acquire needed skills.

CHAPTER III

METHODS

The goal of this research was to determine the impact a technology-based intervention program had on skill retention for a group of third grade special education students in mathematics.

Design

A pretest-posttest quasi experimental design was used in the study given that the experimental group consisted of a "convenience sample" of eight third grade special education students receiving the Baltimore County Public Schools' (BCPS) curriculum through the Scott-Foresman textbook series which focused the content on geometry. In this research, the BCPS unit assessment was used as the pretest and posttest from the geometry unit provided by the county. The dependent variable in this study was the difference in students' achievement on the pretest versus posttest while the independent variable was the technology-based intervention program.

Participants

The study was conducted in a Baltimore County Public School located in a middle class neighborhood. The school's population consists of 892 students in kindergarten through fifth grade, of which, 68% are African American, 10% are white, 4% are Hispanic, 12% are Asian, and 6% are two or more races. The attendance rate for the school is greater than 95% and 33% of the enrolled students, approximately 298 students, qualify for free or reduced lunch.

The eight students in the study were enrolled in third grade. The group consisted of six boys and two girls. The group of students all had individualized education plans (IEP's) and the students were in a self-contained classroom for mathematics since the beginning of the school year. All students in the group were performing below grade level in third grade mathematics. All of the students received the same second grade curriculum, which included basic geometric ideas.

Instrument

The instrument used to measure achievement for all the participants was the unit assessment created by BCPS for the third grade Unit 8 Geometry unit (see Appendix A). This assessment aligns directly with the BCPS third grade geometry curriculum objectives, which directly align with the Maryland State Curriculum. The researcher has administered this assessment with several classes over a four- year period and has seen consistency with the students' performance on classroom activities and daily assessment given throughout the unit and their overall performance on the unit assessment created by BCPS. Based on this informal observation, the researcher finds that the data collected from the unit assessments is a valid measure of the students acquisition of the skills learned throughout the geometry unit.

Procedure

The researcher, a mathematics resource teacher, received permission from the principal of the school to complete the research during morning work, lunch time, or free time during the students' day. As previously stated, all students receive special education services. Students were all taught using the same mathematics curriculum and have received small group mathematics instruction since the beginning of the school year. The study began on February 20, 2013. For three weeks students were taught using the mathematics curriculum for Geometry Unit 7, in the third grade mathematics curriculum guide. Students were all taught using the same manipulatives, given the same daily assignments, and homework assignments. After the three-week period students were given an assessment which consisted of 14 questions: two brief constructed response questions which required students to show their work and explain their answers and 12 selected response questions. After students took the assessment, scores were recorded as the pre-assessment data. After four weeks, students then worked on reviewing and revisiting the geometry skills that they had acquired during the three week teaching period. They used a technology-based intervention program called *Study Island* located on the internet at www.studyisland.com to review the skills assessed on the pre-assessment. This interactive website allowed for students to practice the previously learned skills through an interactive game mode. Students worked on the objectives assigned by the researcher. The researcher assigned all students the geometric objectives assessed on the pre-assessment, with the exception of the angles objective which was not available on the program at their assessment level, in order for students to reinforce the previously learned skill. Students in the study used the program three days a week for 30 minutes a day, for a period of eight weeks, for a total of 720 minutes (12 hours). Students were able to earn ribbons of completion on the technology-based program to help them monitor their progress and work on specific areas they still had not yet mastered. Students worked towards earning five ribbons for the five mathematics objectives assessed on the pre-assessment test. At the end of the of the eight-week period students completed a post-assessment that was identical to the pre assessment. The results of the mathematics pre-assessment, technology-based intervention program and post assessment were collected and analyzed by the researcher.

CHAPTER IV

RESULTS

The primary purpose of this study was to determine the effect a technology-based program, Study Island, had on the skill retention of selected mathematics skills among eight third grade special education students. For purposes of this study, level of skill retention was based upon a comparison of each student's pre-assessment score on a geometry unit test, which was administered to students after completion of the unit through classroom instruction and their post-assessment score administered three months later. This study used a pretest-posttest quasi experimental design given that the experimental group consisted of a "convenience sample" of eight third grade special education students receiving the Baltimore County Public School's (BCPS) curriculum through the Scott-Foresman textbook series which focused the content on geometry. The dependent variable in this study was the difference in students' achievement on the pretest versus posttest while the independent variable was the technology-based intervention program.

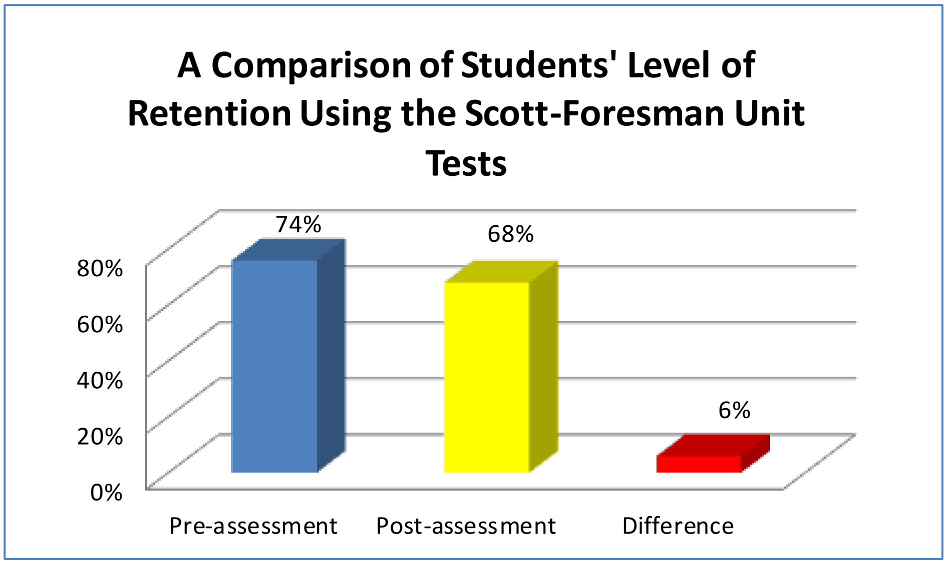
Differences in students' performance on the pre-assessment versus post-assessment are reported in Table I below and in Figure 2.

Table I

A Comparison of Students' Level of Skill Retention Using the Scott-Foresman Pre-assessment versus Post-Assessment Unit Test

Group	Pre-Assessment Results			Post-Assessment Results			Mean Difference Result
Students Receiving Study Island Instruction	N	Mean Scale Score	Standard Deviation	N	Mean Scale Score	Standard Deviation	
	8	74%	1.89	8	68%	0.10	6%

Figure 2



The results suggest that for students receiving the technology–based program *Study Island* there was a 6% decline in their pre-assessment versus post-assessment performance. This decline may have been the due to the students' deficiencies with long-term memory or retrieval of information as stated in their individualized education plans. The 6% decline may also have been a result of the shortness of the test, which made each question worth approximately 6%. Based on this, the decrease in overall score from the pretest to the posttest was the difference of one test question which students consistently answer incorrectly. This question was a question on angles, which was not an objective that was not available for review on the technology-based program *Study Island*. The lack of incremental rehearsal of this math objective may have caused the decrease in the pretest and posttest score. In order to determine whether the difference between students' pre-assessment versus post-assessment performance was statistically significant, a t test for dependent groups procedure was used. The results (t = 0.264, df = 14, p = .7953) suggests that while there was a decline in students' performance, the amount of decline was not statistically significant, and thus could have occurred by chance. Given the above results the null hypothesis that students in the 3rd grade experimental group will show no statistically significant difference in the level of skill retention of previously taught math skills after using a technology-based program for incremental rehearsal should be retained.

CHAPTER V

DISCUSSION

The purpose of the research was to determine if the level of skill retention increased due to incremental rehearsal in a technology-based math intervention program. The null hypothesis of this study was that there would be no statistically significant difference in the level of skill retention of previously taught math skills after using a technology - based program for incremental rehearsal. Based upon the results reported in Chapter IV, there was a 6% decline in students' pre-assessment versus post-assessment results; however, this decline was not found to be statistically significant, and thus the null hypothesis that students in the 3rd grade experimental group will show no statistically significant difference in the level of skill retention of previously taught math skills after using a technology - based program for incremental rehearsal was retained.

In this research the pretest was imperative in determining the skill mastery at the end of the unit and the level of skill retention which occurred on the posttest. Because the pretest and posttest were identical, the students were comfortable with the format. Both the pretest and posttest were given at the same time of day and with the same test administrator. The results on the posttest assessment may have shown a 6% decline due to students' deficiencies with long-term memory or retrieval of information as stated in their individualized education plans. The results may also have shown a decrease due to a lack of incremental rehearsal of the mathematics objective on angles, which was assessed on the pretest and posttest through one test question.

Implications

The study can be valuable to teachers who use this type of technology-based program. The study indicates that students did not learn new information, but did reinforce skills that they previously showed knowledge of understanding. When examining the results of the program, the researcher was able to see that skills with which students struggle on the pre-assessment were skills they continued to struggle with on the technology-based program. This was evident given the percentage of questions pertaining to particular skills that they answered correctly. Skills which students showed understanding of on the pre-assessment yielded higher percentage scores on the technology-based program. The program allowed for student to incrementally rehearse skills that they had previously acquired, but did not allow for them to gain new knowledge or clarify misconceptions of skills.

The use of a technology-based program should be examined carefully to ensure that all objectives are present for the incremental rehearsal of desired skills. Teachers should ensure that when assigning objectives to students that they have had direct instruction on the skill in order for incremental rehearsal to be effective. Educators should also use the results of the technology-based program to determine areas where students may need further direct instruction in order to move past the initial stage of skill learning. While a technology-based program may be an effective way to incrementally rehearse they should not be the only method for intervention.

Potential Threats to Internal Validity

As previously indicated, one of the major potential problems of internal validity in this study was the absence of a control group. Because of this absence, determining if the students retained the skills because of the technology-based intervention program or because of other factors, such as review in math class, is uncertain.

Another potential problem was the size of the group itself. Because there were only eight students participating, the chance for measurement error in the group's overall performance (i.e. variability) was a major concern.

The length of the test also is a problem of internal validity because the percentage value of each question is increased with the shortness of the test. When examining the data the large percentage decrease appears to show a larger loss of skill than one test question. It also did not allow the researcher to determine if the participants answered the questions correctly or by chance because each objective is addressed in only one or two test questions.

Potential Threats External Validity

The ability to generalize results of this study to similar students in other schools within county is a major problem of external validity. The students involved basically represented a convenience sample and thus there was no random assignment of students to groups. The convenience sample causes a major problem to the study's external validity.

Relationship to Existing Literature Reviews

According to the Encyclopedia of Cognitive Science (2005), a skill is "an acquired ability that has improved as a consequence of practice" (Skill Learning, 2005, Introduction, para. 1.) Thus, skill learning, or skill acquisition, is improvement through practice or continually conducting the same activity (Skill Learning). The results of this study show no statistically significant difference in the level of skill retention for eight special education students who used a technology-based program to continually practice the same skills.

Current research contends that students with learning disabilities often struggle due to memory deficits, inability to attend to specific aspects of a task, and a lack of motivation to complete tasks (Miller & Hudson, 2007). According to Passolunghi and Mammarella (2012), students with learning disabilities can benefit most and develop mathematics competence through the use of explicit instruction and evidence-based practices. In this study, the use of explicit instruction proves to be where students made the most gains in skill acquisition and the use of the technology-based program appeared to maintain the skills gained from the explicit mathematics instruction; however, it was unclear whether this happened by chance.

According to this research there are several stages to skill learning: the initial, intermediate and final stage. In these stages skills are refined, restructured, and become routine by the final stage of skill learning. In this study the stages of skill learning are supported by the results on the pretest and posttest assessments. The students showed development through the initial and intermediate stages of skill learning. The participants' results on the pretest show that through the direct instruction they are able to begin acquiring the skills and beginning to refine the skills in the intermediate stage. Research indicates that the intermediate stage for skill learning can extend for different periods of time based on the skill being acquired. Through the use of the technology-based program, participants were able to continually rehearse the skills to become more proficient, but as the research and the results of the study indicate, they may have needed more time to move to the final stage of skill acquisition (Skill Learning, 2005).

Some Suggestions for Future Research

This study may lead to future research in the effectiveness of technology-based programs. Future research should include a control group in order to clearly determine if the technology-based program was the sole factor in the level of skill retention. Without a control group, it is unclear if there were other factors that affected the students' performance on the post-assessment. In addition, a larger sample size should be used which includes a more diverse group of students. Random assignment of students to the groups would allow for the external validity of a future study to dramatically increase.

Future researchers should also ensure that the objectives being reviewed on the technology-based program cover all objectives on the assessment in order to ensure that students are incrementally rehearsing all of the skills they will be assessed on in the posttest. An additional recommendation is to increase the length of the assessment. By increasing the length of the pre-test and post-test more accurate data can be collected about the level of skill retention. Finally, extending the length of time participants use the technology-based program may provide the researcher with more time to have students focus on specific objectives when working on the technology-based program.

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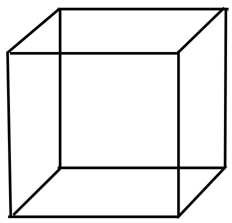
Appendix A

Geometry and Measurement

1. Which statement describes a cube?



- ○ a. 4 faces, 8 vertices, and 6 edges
- ○ b. 8 faces, 8 vertices, and 8 edges
- ○ c. 6 faces, 8 vertices, and 8 edges
- ○ d. 6 faces, 8 vertices, and 12 edges

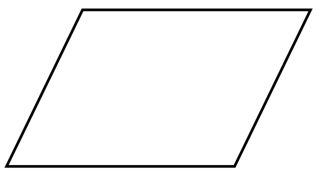
2. All of the faces of a cube are congruent. Name the shape of each face of a cube.

- ○ a. Circle
- ○ b. Square
- ○ c. Triangle
- ○ d. Hexagon

3. How many sides and vertices does an octagon have?

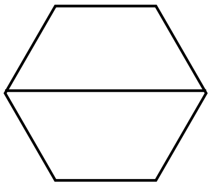
- ○ a. 4
- ○ b. 5
- ○ c. 6
- ○ d. 8

4. Name the quadrilateral.



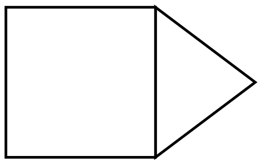
- ○ a. Trapezoid
- ○ b. Rectangle
- ○ c. Square
- ○ d. Parallelogram

5. What two shapes are created when the hexagon below is divided?



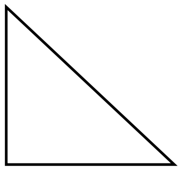
- ○ a. Triangles
- ○ b. Hexagons
- ○ c. Trapezoids
- ○ d. Pentagons

6. Identify the new shape that is created by combining a triangle and a square.



- ○ a. rectangle
- ○ b. pentagon
- ○ c. hexagon
- ○ d. octagon

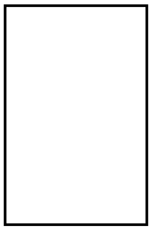
7. Identify the number of right angles in this triangle.



- ○ a. 0
- ○ b. 1
- ○ c. 2
- ○ d. 3

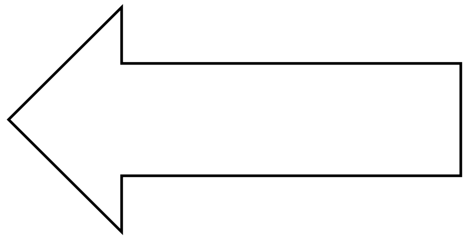
8. How many lines of symmetry does a rectangle have?

- ○ a. 1
- ○ b. 2
- ○ c. 3
- ○ d. 4



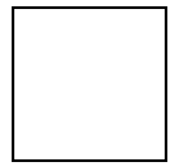
9. The teacher drew the figure below on the chalkboard.

Step A
Draw a line of symmetry on the figure.



Step B
Explain why your line of symmetry is correct.
Use what you know about symmetry in your explanation.
Use words and/or numbers in your explanation.

10. How many lines of symmetry does a square have?



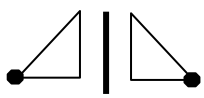
○ a. 1

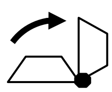
○ b. 2

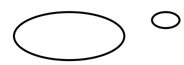
○ c. 3

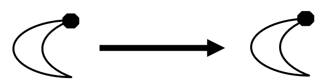
○ d. 4

11. Which pair of shapes shows a slide?

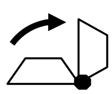
○ a. 

○ b. 

○ c. 

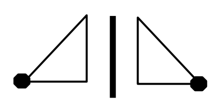
○ d. 

12. Which pair of shapes shows a turn?

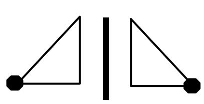
○ a. 

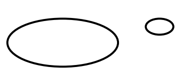
○ b. 

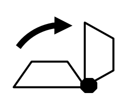
○ c. 

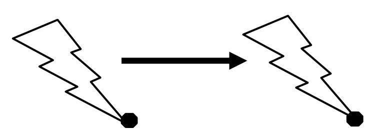
○ d. 

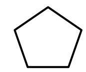
13. Which pair of shapes shows a flip?

○ a. 

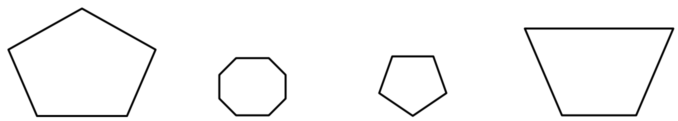
○ b. 

○ c. 

○ d. 

14. Sam is sorting congruent polygons. This is Sam's polygon. 

Step A
Circle the figure that is congruent to Sam's polygon.



Step B
Explain why your answer is correct.
Use what you know about congruent figures in your explanation.
Use words and/or numbers in your explanation.