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The Effectiveness of Assistive Technology in the Inclusive, Secondary Mathematics Classroom

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The Effectiveness of Assistive Technology
in the Inclusive, Secondary Mathematics Classroom

by

Krystal Barber

A thesis submitted to the Department of Education and Human Development of the State University of New York College at Brockport in partial fulfillment of the requirements for the degree of Master of Science in Education

November 11, 2009
The Effectiveness of Assistive Technology
in the Inclusive, Secondary Mathematics Classroom

by

Krystal Barber

APPROVED BY:

[Signature]
Advisor

[Signature]
Director, Graduate Programs

11/18/09 Date
11/19/09 Date
Dedication

I dedicate this study to my Mother. Throughout my life she has been my rock. I know that this process of earning my Master's degree has not been easy; in fact it has been quite stressful. However, my mother has been by my side, step by step. There is no way that I would have been able to come as far as I have without her support and love.
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Abstract

Assistive technology has been an essential part of society. People use assistive technologies at many different times within the normal course of a day without their knowledge. Educators can use assistive technologies to aid their students with disabilities and without disabilities. Assistive technology devices can be used to bridge the physical, sensory, or cognitive impairments within the mathematical classroom. This study shows the connections between the use of assistive technology in an inclusion mathematics classroom and their academic achievement, self perceived satisfaction, and teacher's perception of the effectiveness. Assistive technologies proved to be noteworthy when used in the inclusive, secondary mathematics classroom.
Curb cuts, curb slopes, optical character readers, closed captioning along with many other types of technology were initially developed to assist persons with disabilities. Curb cuts at street corners were originally designed to accommodate people with orthopedic disabilities. However they are more frequently used by strollers or shopping carts than by people with wheelchairs or walkers. The technology developed to assist individuals to read written text, optical character readers, have been redesigned for the office to reduce the amount of time in data entry. Closed captioning television technology, developed to enable persons with hearing impairments to watch television, is now used extensively in noisy sports restaurants.

Technology can be a great equalizer for individuals with disabilities that might prevent full participation in school, work, and/or the community. While this is most evident in individuals with mobility, hearing, or vision impairments, it is also true for individuals with disabilities in cognition, perception, and academic fields.

Teachers of children with disabilities have more access to technology, which can be utilized in a more powerful and efficient level, than ever before. These tools enable teachers to offer new and more effective means of learning with differentiating instruction for a broad range of multiple student learning needs. Educators are using computers and other assistive technologies as tools to deliver and facilitate learning beyond drill and practice, to provide environments that accommodate learning, and to ensure enhanced and equitable learning environments to all students. Computer and computer-based advances are leading to classroom reorganization. Assistive
technology has opened many educational doors to students, particularly to students with disabilities. Solutions of assistive technologies are accommodating physical, sensory, or cognitive impairments in many ways.

Students with disabilities are being included in general education classrooms at an increasing rate. Although progress has been made toward including students with disabilities into the general education curriculum, these students continue to be high risk for academic failure and under performance, in math particularly.

Mathematics instruction has undergone a reform movement that emphasizes critical thinking, communication, and collaborative learning over rote memorization or application of formulas, procedures, and basic skills. Teachers are under great pressure to increase the academic performance of all students no matter the level of ability, especially in the areas of reading and mathematics. The concern over student performance or lack thereof has prompted legislation to address the issue of poor academic performance. The most notable piece of legislation is the No Child Left Behind (NCLB) Act of 2001, which requires all students, including those with disabilities, to perform at a proficient level on state assessments.

Purpose

The purpose of this two-phase, sequential mixed methods study is to explore student and teacher views with the intent of using this information to develop and test an assessment with a sample from a population. The first phase is a qualitative exploration of assistive technology in the secondary, inclusion mathematics classroom by collecting observational data from students and teachers at a senior
high school in western New York. Themes from this qualitative data is then
developed into an assessment so that research questions can be tested that relate to
facilitation of learning with assistive technology for inclusion mathematics
classrooms at the same senior high school in western New York.

Definitions

For the purpose of this study the following terminology has been defined:

- **Assistive technology** is technology that aids in the learning or teaching of
  students. Assistive Technology is any item, piece of equipment, product or
  system, whether acquired commercially, off the shelf, modified, or customized
  that helps make life easier for a person who has a disability. Assistive
  technology devices may range in complexity from a strip of Velcro purchased
  over the counter to a customized voice-activated computer.

- **Learning disabilities** are a variety of disabilities that affects the learning ability of
  a person or student.

- **Inclusion** is a term used to define an educational experience for a student with
  disabilities that does not exclude the student from typical classroom
  participation depending on educational needs and abilities, contrarily the
  student remains in the classroom participating in the same activities as the
  other regular education students.

- **Understanding** is obtained by students when generalizations about the
  curriculum are made and applied to examples in previously unencountered
  circumstances. This is when a student is able to know when, how, what,
where, and why we use a method of solving a problem, as well as is able to transfer knowledge from one topic of discussion to another unfamiliar situation.

- **Satisfaction** is obtained when a student believes that he or she understands the material and is proud of the accomplishment.

- **Academic achievement** is obtained when a student increases his or her academic grades within a particular class, quarter, unit, chapter, or lesson.

- **Effective** will be used as the means of producing a positive effect. It is also to mean that the people involved feel clearly that all their current needs are met and they leave feeling good about themselves, the curriculum, their knowledge, and understanding of the curriculum.

**Problem Statement**

The following research questions will guide the study:

- How does assistive technology facilitate the learning of students with disabilities with respect to inclusion classrooms surrounding the secondary mathematics curriculum?

- What are student perceptions of the ways in which assistive technology affects their learning and satisfaction in mathematics?

- What are teacher perceptions of the ways in which assistive technology affects the learning processes and satisfaction of students with disabilities in mathematics?
Rationale

The mixed method was chosen in this study because of the cognitive deficit of the participants. Due to the degree of disabilities of some of the students the Likert scale was utilized to give the students guided direction for their responses. The qualitative portion of the research was utilized to discover themes for research and to exploit the voices of the participants.

Significance

Proficiency in mathematics is strongly associated with students' access to higher education and quality employment. That is, students who complete advanced mathematics courses are more likely to succeed in college and obtain better paying jobs than those who don't. Assistive technologies are devices that students with disabilities can exploit to even out the diversity between students with disabilities and students without. (Foegen, 2008)

Institutional Review Board

Permission from the Institutional Review Board of the College at Brockport was sought in the fall of 2008. According to IRB, the study was classified as a Category II. This was determined from the following categories:

- Research on educational curricula, records, or teaching methods involving normal educational practices.
- Research involving the use of educational tests if information taken from these sources is recorded in such a manner that subjects cannot be identified.
• Research on individual or group behavior of normal adults where there is no psychological intervention, physiological intervention or deception.
• Interviews and non-mailed surveys on non-sensitive topics (SUNY College at Brockport, 2009).

Prior to receiving approval for the proposed thesis study I completed a module in the summer of 2008 through the Collaborative Institutional Training Initiative pertaining to human research for the fulfillment of EDI 600 (Understanding Educational Research) at the State University of New York College at Brockport. At that time any research that was completed was considered to be classroom research, which was exempt by the IRB (see Appendix A).

I sought the permission to administer this study in the participating teacher's classroom from the building principal. All data collected during the study was contained in a secure, locked cabinet. All participants are known only as pseudonyms; true identity of the students is only known by the researcher to guarantee the confidentiality of all participants. The classroom was chosen because of the diversity of students available to participate with assistive technology in mathematics; however the findings are not generalizable because of the small sample size, the fact that the study was conducted in a classroom in which I had constant contact with the participants, and the demographics of the participants.
REVIEW OF LITERATURE

National Concerns within Mathematics

Prior to No Child Left Behind, the passage of the Technology-Related Assistance for Individuals with Disabilities Act of 1988 contributed to the increased attention of the role that assistive technology can have in improving the functional needs of individuals with disabilities. The Assistive Technology Act of 1998 further clarifies and extends the terms and/or programs originally introduced in the Technology-Related Assistance for Individuals with Disabilities Act of 1988 and its 1994 amendments. The Assistive Technology Act of 1998 includes findings regarding the relationship between assistive technology devices and how persons with disabilities may use them to perform tasks and skills associated with education, work, and social/cultural life. (Congress, 1998)

The Individuals with Disabilities Education Act (IDEA) Amendments of 1997 requires that the assistive technology needs of all students with disabilities be considered as part of the Individual Educational Program planning process. Many of these students can benefit from inclusion and a specialized assistive technology device for its great potential for enhancing their capabilities (Zhang, 2000). IDEA 97 puts emphasis on “providing greater access by children with disabilities to the general curriculum and to educational reforms, as an effective means of ensuring better results for these children” (IDEA 97, 1997). According to Li & Edmonds (2005), technology is necessary to teach and learn mathematics by increasing student learning and manipulation of the mathematics that is taught.
The decreasing math performance of United States students had led to meticulous standards for teaching and learning mathematics that relies on increased student accountability (Maccini, Mulcahy, & Wilson, 2007). The National Council of Teachers of Mathematics developed standards for teaching math that highlights conceptual, mathematical reasoning, and problem-solving skills that emphasize real-world application (Maccini, Mulcahy, & Wilson, 2007). In addition government and professional groups have urged educators to help all students acquire mathematical preparedness for post-secondary education and employment (Bottge, Rueda, Serlin, Hung, & Kwon, 2007).

Students with disabilities are not the only ones who struggle with mathematics. Large numbers of U.S. students continue to score below the basic level in mathematics. It has been concluded that 23% of fourth grade students and 32% of eighth grade students scored below the basic level (Witzel & Riccomini, 2007). There is a need to develop more efficient and effective mathematics instructional procedures for low performing students with and without disabilities.

Specific Issues of Students with Disabilities in Mathematics

Difficulties in mathematics are a common characteristic of students with disabilities (Witzel & Riccomini, 2007). In problem solving, students with disabilities have an inability to generalize obtained problem-solving skills from one situation to another. This has often hindered their success in solving word problems (van Garderen, 2007). Students with disabilities experience mathematical difficulties for a variety of reasons, including poorly developed number sense, poor processing
abilities, language and literacy difficulties, math anxiety, and inefficient memory processes (Graham, Bellert, & Pegg, 2007). Students with disabilities characteristically are poor strategic learners and problem solvers; they manifest strategy deficits and differences that obstruct performance, particularly on tasks requiring higher level processing. These students need clear instruction in selecting strategies appropriate to the task, applying the strategies in the context of the task, and self-assessing their execution (Montague, 2008).

By giving students an opportunity to take part in meaningful problem solving activities, mathematics teachers are advised to expand their students’ knowledge of math concepts. The National Council of Teachers of Mathematics (NCTM) stated that learning experiences should help “students become confident in their ability to tackle difficult problems, eager to figure things out on their own, flexible in exploring mathematical ideas and trying alternative paths, and willing to persevere” (Bottge, Rueda, LaRoque, Serlin, & Kwon, 2007, p. 96). Special education teachers have also advocated for changes in instructional practices for students with learning disabilities in math that reflect a more balanced approach between problem-solving and basic skills instruction. (Bottge, Rueda, LaRoque, Serlin, & Kwon, 2007)

*Inclusion within Mathematics*

In 2002, according to the United States Department of Education (as cited in Fahsl, 2007), 48.2% of students with disabilities were educated primarily in the general education classrooms. It is expected that all students attain mathematical proficiency, not just college-bound students, and that all teachers should provide
high quality mathematics instruction to their students (Brown, Stein, & Forman, 1996), which would be more efficiently addressed in an inclusion classroom.

One of the primary goals of inclusion is to enhance students' social competence and to change the attitudes of teachers and students without disabilities. Miller and Mercer (1997) note that few modifications are made for students with disabilities who are placed in general classrooms. The inclusion classroom makes considerable demands on teachers as they cater for a range of student abilities and needs (Graham, Bellert, & Pegg, 2007). However in most instances, the accommodations can be implemented for the whole class and will help all students more fully comprehend the concepts and skills being taught (Fahsl, 2007; Lewis, 1996).

Teaching Students with Disabilities in Mathematics

Despite the extent of what is known, given the number of students who have failed to master basic mathematical skills, questions must be raised concerning whether we know all that we need to in order to help every child achieve high levels of mathematical proficiency. Students with disabilities have many diverse needs when it comes to learning mathematics. As a result, teaching students with special needs sometimes requires teachers to adjust the learning environment. To effectively teach students with disabilities, teachers must know when to make adjustments, how to make adjustments, and what adjustments to make to maximize students' performance. (Hong & Ehrensberger, 2007)
Higher expectations coupled with the sluggish math performance of students with disabilities have led some special educators to question whether traditional instructional methods for students with learning disabilities are appropriate and adequate (Bottge, Rueda, Serlin, Hung, & Kwon, 2007). Students with disabilities are more likely than their peers to identify mathematics as their least favorite high school class. They also believe providing more assistance, altering typical teaching styles, incorporating group work, and increasing the interest level of the instruction are strategies that would assist them in improving their performance (Foegen, 2008).

Word problems were ranked as most problematic for students with learning disabilities and math weaknesses (Bryant & Bryant, 2008). The majority of special educators agree that students should be active learners who know how to derive meaning from math instruction strategically and efficiently (Butler, Beckingham, & Novak Lauscher, 2005).

How Does Assistive Technology Enhance Mathematics Performance?

At present, there is a general agreement that students with disabilities benefit from assistive technology allowing students to achieve educational goals that they could not otherwise accomplish in the same manner (Lewis, 1996; Rapp, 2005). Assistive technology helps students with disabilities interact with content to develop self-regulating knowledge and skills. "To persons with disabilities, technology is a means of empowerment; denying them that option exacerbates their disabilities effects" (Lewis, 1996, p. 25). The devices do not replace traditional teaching methods, but supplement methods to enhance student learning (Riley,
Beard, & Strain). General education teachers can implement simple mathematics accommodations without extensive preparation time (Fahsl, 2007).

"Assistive technology can be used to reduce working memory load" (Zentall, 2007, p. 232). The effectiveness of different assistive technological approaches enhances the mathematics performance of students with disabilities (Cawley, Foley, & Doan, 2003). Scaffolds built into software and applications have proved important for students with disabilities who often need additional support and practice to adequately acquire and retain more complex math concepts (Bottge, Rueda, LaRoque, Serlin, & Kwon, 2007).

Varieties of Assistive Technologies

Assistive technologies must provide physical, sensory, and cognitive access as well as sufficient support to ensure success of students with disabilities. Higher levels of learning and performance are only achieved as a result of engagement in tasks of increasing difficulty and complexity (Edyburn, 2007). At present, the typical application of assistive technology for students with disabilities seems to be those that are computer based (Lewis, 1996). Some examples of these high-tech assistive technologies include:

- Productivity tools (i.e. Microsoft Excel, spreadsheets, charts, database applications)
- Presentation and multimedia tools (i.e. Microsoft PowerPoint)
- Computers
- Communication boards
Assistive Technology in Math

- Environmental control systems
- Calculators with speech output
- Electronic equipment
- Interactive video disc programs to facilitate the attainment of math concepts and problem solving skills
- Visual representation software
- Virtual manipulatives
- Dynamic geometry software
- WebMath to provide calculating and instructional support for solving math problems
- MathPlayer
- Handheld devices such as personal digital assistants and Tablet PCs to provide convenient input interfaces that enable students and teachers to undertake their learning and teaching activities using styli instead of traditional keyboards (Liu, Chou, Liu, & Yang, 2006; Soiffer, 2005; Cooper, 2007; Edyburn, 2007; Innes Helsel, Hitchcock, Miller, Malinow, & Murray, 2006; Lewis, 1996; Behrmann, 1998; Riley, Beard, & Strain)

These assistive technologies do not dilute the curriculum’s content. Rather, they provide students with more time in order to be able to cover as much content in as much depth as their non-disabled peers, thus increasing their learning and ability to generalize across content areas (Rapp, 2005). Within the inclusion classroom it
It has been found that the flexibility of digital curriculum makes it easier than ever to adjust the challenge level of academic tasks (Edyburn, 2007).

Low-tech types of assistive technology in most cases can be just as effective as an expensive high technology device (Riley, Beard, & Strain). These devices are typically manually, not electronically operated (Behrmann, 1998). These assistive technologies are also less expensive, such as:

- Graph paper - Allowing students to use graph paper for all mathematical work, graph paper can be easily be enlarged for students who have fine motor-skill problems, visual deficits, or simple poor handwriting
- Number lines
- Rulers
- Pencil grips
- Mouth sticks
- Mechanical hoists
- Geometry tools
- Blocks and tiles
- Three dimensional objects
- Graphic organizers
- Alternatives to standard lined paper
- Highlighters - Directions on an assignment can be highlighted as a reminder for students of what needs to be done
- Multiplication charts
- Manipulatives (i.e. counters, paperclips, bingo chips, stickers)
- Cut or folded strips of paper for fraction instruction
- Cue cards of strategy steps
- Calculators
- Mnemonics
- Color coding (Riley, Beard, & Strain; Behrmann, 1998; Innes Helsel, Hitchcock, Miller, Malinow, & Murray, 2006; Ives, 2007; Fahsl, 2007; Maccini & Gagnon, 2006)

*Perceptions of Students with Disabilities, Mathematics, and Assistive Technology*

Students with learning disabilities may be at risk for low self-perceptions of competence, which can lead to less determination in academic learning. According to Montague (as cited in Butler, Beckingham, & Novak Lauscher, 2005) students with disabilities are at risk for less positive attitudes toward mathematics. Theorists found that students with disabilities perceived mathematics problems to be more difficult, required more time to complete, and they used fewer strategies than their non-disabled peers to solve problems (Maccini, Mulcahy, & Wilson, 2007). Significant positive effects were found for attitudes and self-concept in mathematics when assistive technology, in the form of a calculator, was utilized (Hembree & Dessart, 1986).
Barriers to Assistive Technology Implementation

Despite the increased attention to and awareness of the potential of assistive technology to help individuals access the general curriculum and acquire transitional skills, as reflected in the federal legislation, several barriers remain. Assistive technology is unavailable to many students with disabilities and their families. High costs of equipment and lack of information regarding assistive technology are often primary barriers. Another major obstacle is that professionals' lack knowledge about the technology. This combined with the lack of ongoing support can lead to the underutilization of assistive technology devices. (Alper, 2006; Li & Edmonds, 2005)

Assistive technology has improved in all aspects, however there is still a lack of time and training available to teachers to allow them to implement technology in potentially important and beneficial ways. For most students, the computer is highly motivating and often quite necessary. Of course, engagement by itself does not guarantee that students will learn anything substantial (Bottge, Rueda, LaRoque, Serlin, & Kwon, 2007). Consequently a computer's response to mistakes can be less threatening than the personal response of a teacher, peer, or parent (Bley, 2001). “The most powerful technology is worthless if its operation cannot be mastered, any technology is worthless if its potential users are denied access to it” (Lewis, 1996, p. 23). Thus, if assistive technologies are not utilized in the classroom, students cannot work to their greatest potential.
METHODOLOGY

Participants

Taking graphic organizers and manipulatives, as a range of assistive technologies, I observed a group of students with and without disabilities to determine the effectiveness of the technology introduced. Participants included 18 students. All students were engaging in the New York State Class of Geometry in a class of 29. However the curriculum was determined by the individual school district since the specific class was a non-regents course, titled as Applied Geometry. Students were assigned by the school administration per the students' schedule, curricular needs, and continuum of services per the district's Director of Pupil Services and Committee on Special Education for each individual student. This class was composed of students with disabilities and general education students; this particular class contained 12 students with disabilities, seven of which were participants. Participants in the study encompassed the following disabilities:

- Learning Disability within working memory and academic fluency
- Learning Disability with a delay in language processing skills and listening comprehension which effects oral expression and classroom achievement
- Other Health Impairment; diagnosed with ADHD and Bipolar Disorder
- Other Health Impairment; diagnosed with a significant delay in processing and memory skills which interferes with participation in age appropriate activities
• Learning Disability with significant delays in social, emotional, reading, and math skills
• Learning Disability with significant delays in processing which impacts overall performance
• Other Health Impairment with significant delay in attention skills

According to the participants' Individualized Educational Programs (IEP) the following services and support were required in the classroom at all times:

• Frequent checks for understanding
• Monitoring task completion
• Use of calculator
• Use of word processor
• Organizational skills check
• Preferential seating
• Communication needs from extended processing time
• Copy of class notes
• Refocusing and redirection
• Additional time to complete tasks
• Use of a graphic organizer
• Environmental support of a counselor
• Study/Test taking skills
• Re-teaching of materials
- Monitoring of off task behavior
- Guided notes
- Monitoring of use of agenda for organization
- Use of a spell check device
- Academic support
- Homework/assignment load monitored
- Preview of vocabulary
- Behavior Intervention Plan

Some if not all of these services and supports can be accomplished using some sort of assistive technology. (Teachers, 2008)

Table 1

<table>
<thead>
<tr>
<th>Grade of Students with Disabilities</th>
<th>(Participants Only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenth</td>
<td>5</td>
</tr>
<tr>
<td>Eleventh</td>
<td>1</td>
</tr>
<tr>
<td>Twelfth</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Grade of Regular Education Students</th>
<th>(Participants Only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenth</td>
<td>7</td>
</tr>
<tr>
<td>Eleventh</td>
<td>4</td>
</tr>
<tr>
<td>Twelfth</td>
<td>0</td>
</tr>
</tbody>
</table>
Setting

The research was conducted within a school district located in a rural community in western New York. The community ranged from low socioeconomic status to high middle class families with a median household income of $61,616 (Onboard Informatics, 2007). A vast majority of the population was Caucasian (91%), with minorities including African-American (6%), Asian (2%), and Hispanic (2%) (Office of Information and Reporting Services, 2008). Out of the 1100 student that were populating in the senior high school, 9% received free lunches and 6% had reduced priced lunch (Office of Information and Reporting Services, 2008). In this school district, the senior high school model included students in grades 10 to 12. Students that were provided learning assistance were required to have an Individualized Educational Program (IEP). Of the 18 participants in the Applied Geometry classroom, 7 were female. Of the 18 students, 2 were African American, 1 was Asian American, and the remainders were Caucasian.

PROCEDURE

Prior to the Intervention

In this particular classroom assistive technology was not widely used. Most of the students with disabilities benefited from a modification of the curriculum however it was assumed that the accommodations of an assistive technology device would have been advantageous. School special education and mathematics teachers were aware of some assistive technologies, but were unaware of their benefits or usage. The educators that participated were introduced to assistive technologies in
the secondary mathematics classroom and informally trained how to implement a small sampling of these particular technologies. It was believed that some factors would surface, these included:

- Student's being uncooperative
- Student's believing that the assistive technologies would not benefit them
- Student's wanting assistive technology devices to be used at all times
- Student's playing with assistive technology devices and not understanding there educational context
- Student's not using the devices properly.

**During the Intervention**

Both the regular education teacher and special education teacher in the room were aware of the assistive technology devices being used with the students. However they did not modify their teaching strategies because of the assistive technology devices. The particular assistive technologies that were administered included: graphic organizers, manipulatives, solid figures, paper cut outs, origami figures, calculators, and individual white boards. The implementation of these devices did not cause a change in the teaching strategy of the teachers but was incorporated into the daily lessons.

**After the Intervention**

After the intervention was administered, the teachers and the participants in the room were interviewed as to the effectiveness of the assistive technology devices.
Researcher's Role

Being certified by the Department of Education in New York State in both mathematics and special education, I had both a professional and personal interest in the subject. I wanted to know the effectiveness of assistive technology in the secondary mathematics inclusion classroom and how I could apply these devices in my own future classroom. It was my goal to teach math in a way that builds satisfaction, collaboration, cooperation, and decision-making skills as they apply to mathematics in the inclusion classroom. As a graduate student, I had been studying Secondary Adolescence Mathematics to complete a Master's of Science in Education. At the time of data collection, I was certified to teach Mathematics grades 5-12 and Students with Disabilities grades 7-12. Throughout my studies, there was an increase of the amount of technology being used within the classroom; this sparked my interest in assistive technologies within the inclusion mathematics classroom. As the Teacher's Assistant in the classroom, I was a complete participant, concealing my role as a researcher.

Researcher's Bias

There was some bias on my part of being a complete participant because the primary setting of this study is in a classroom in which I was a permanent figure as a Teacher's Assistant. In addition, I believed that exposing the students to assistive technologies would better their educational experiences and increase their satisfaction in their own mathematical abilities.
Assumptions

There were assumptions that I made in performing this study. I assumed that the classes would be conducted in a block schedule, with each class period lasting 85 minutes. I also assumed that all students would participate and be present for a majority of the time that the study was conducted in order to be exposed to all of the assistive technology devices used.

Limitations

This study was limited by a number of factors. First, the small population size was a limitation. The fact that I performed this study in a classroom in which the students were familiar with my presence is a further limitation. Due to budget constraints, I was not able to supply all possible assistive technologies to the participants; therefore I focused more on low-tech devices. I collected field notes during the classes that I was instructing; therefore it is possible that the observational notes were not as detailed as if I were not a complete participant.

This mixed methods observational study focused on behavioral, cognitive, and academic outcomes. The observation took place in an Applied Geometry classroom for 85 minutes during the Geometric Solids unit. Observations of students with disabilities and students without disabilities using assistive technology were compiled through detailed field notes. Careful attention was paid to the mathematical focus of the lesson, students' participation, as well as interactions between the teachers and the students in a co-teaching setting. A baseline observation was conducted in correlation with field note observations,
questionnaires, and interviews. Academic data has been synthesized by comparing students' grades prior to the intervention and after the intervention. All tests taken prior to the intervention were averaged and compared to the assessment grade after the intervention.

Since the study was being conducted during one content unit this was a possible limitation. The data could have been skewed because of the students' prior knowledge of the subject matter. The class composition, limited classroom management, and frequent absences are limitations that are displayed by this particular classroom. As a whole this class was:

- Talkative
- Disrespectful
- Unorganized
- Obnoxious
- Loud
- Uncooperative
- Combative

In the beginning of the school year no clear rules or expectations were established by the teachers, hence the class has had severe classroom management concerns and became increasingly out of control. During the intervention modifications and adjustments were required because of the students' behavioral issues. An example of this was that additional practice time was required towards the end of the unit for
the students’ benefit because student behavior had restricted other students’ learning.

**The Intervention Unit**

Table 3

<table>
<thead>
<tr>
<th>Day</th>
<th>Objective</th>
<th>Activities</th>
<th>Assistive Technology Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Properties of Geometric Solids</td>
<td>• Surprise Pouches &lt;br&gt;• Origami Figures</td>
<td>• Solid Wood Geometric &lt;br&gt;• Paper Cut Outs &lt;br&gt;• Characteristics Graphic Organizer</td>
</tr>
<tr>
<td>2</td>
<td>Venn Diagrams and Vocabulary</td>
<td>• Finish Origami Figures &lt;br&gt;• Venn Diagrams &lt;br&gt;• Vocabulary Guided Notes</td>
<td>• Paper Cut Outs &lt;br&gt;• Venn Diagrams</td>
</tr>
<tr>
<td>3</td>
<td>Surface Area</td>
<td>• Quiz &lt;br&gt;• Surface Area Notes &lt;br&gt;• Guided Practice</td>
<td>• Paper Cut Outs &lt;br&gt;• Calculator &lt;br&gt;• Surface Area Graphic Organizer</td>
</tr>
<tr>
<td>4</td>
<td>Volume</td>
<td>• Quiz &lt;br&gt;• Volume Notes &lt;br&gt;• Formula Sheet &lt;br&gt;• Guided Practice</td>
<td>• Paper Cut Outs &lt;br&gt;• Calculator &lt;br&gt;• Volume Graphic Organizer &lt;br&gt;• Formula Sheet</td>
</tr>
<tr>
<td>5</td>
<td>Characteristics Review</td>
<td>• Concentration &lt;br&gt;• Response Cards</td>
<td>• Paper Cut Outs &lt;br&gt;• Calculator &lt;br&gt;• Formula Sheet</td>
</tr>
<tr>
<td>6</td>
<td>Surface Area Review</td>
<td>• Guided Practice &lt;br&gt;• Group Practice &lt;br&gt;• Individual Practice</td>
<td>• Paper Cut Outs &lt;br&gt;• Calculator &lt;br&gt;• Formula Sheet</td>
</tr>
<tr>
<td>7</td>
<td>Volume Review</td>
<td>• Quiz &lt;br&gt;• Guided Practice &lt;br&gt;• Group Practice &lt;br&gt;• Individual Practice</td>
<td>• Paper Cut Outs &lt;br&gt;• Calculator &lt;br&gt;• Formula Sheet</td>
</tr>
<tr>
<td>8</td>
<td>Overall Review</td>
<td>• Guided Practice &lt;br&gt;• Group Practice &lt;br&gt;• Individual Practice</td>
<td>• Paper Cut Outs &lt;br&gt;• Calculator &lt;br&gt;• Formula Sheet</td>
</tr>
<tr>
<td>9</td>
<td>Assess Student Knowledge</td>
<td>• Unit Exam</td>
<td>• Paper Cut Outs &lt;br&gt;• Calculator &lt;br&gt;• Formula Sheet</td>
</tr>
</tbody>
</table>

**RESULTS**

Students were given a questionnaire to complete at the end of the instruction, consisting of qualitative and quantitative questions (see Appendix B). The
questionnaire contained several Likert scales and open-ended questions with additional area for comments. Students rated on a 1 to 5 scale (1 being strongly disagree, 5 being strongly agree) their satisfaction and perceived effectiveness of the assistive technology devices overall and, specifically, of the use of assistive technology within the class. Furthermore, the participants were asked to rate on the 5-point scale whether they would continue to use the strategy and if they would recommend it to other students. The open-ended questions required the students to report what they liked the most and the least about the utilization of the assistive technology. From access to the teachers’ grade books, students’ grades were detailed and analyzed as to the academic effectiveness of the assistive technology.

The student responses to the questionnaire are as follows:

Table 4

<table>
<thead>
<tr>
<th>Responses to Likert Questions</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree or Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoyed using the assistive technology.</td>
<td>4.76%</td>
<td>9.52%</td>
<td>28.57%</td>
<td>42.86%</td>
<td>14.29%</td>
</tr>
<tr>
<td>I feel more satisfied in my mathematical abilities after using the assistive technology devices.</td>
<td>0.00%</td>
<td>9.52%</td>
<td>47.62%</td>
<td>33.33%</td>
<td>9.52%</td>
</tr>
<tr>
<td>Assistive technology devices help me communicate.</td>
<td>9.52%</td>
<td>9.52%</td>
<td>42.86%</td>
<td>23.81%</td>
<td>14.29%</td>
</tr>
<tr>
<td>Assistive technology devices help me in mathematics.</td>
<td>0.00%</td>
<td>4.76%</td>
<td>38.10%</td>
<td>47.62%</td>
<td>9.52%</td>
</tr>
</tbody>
</table>
I believe that the assistive technology devices make me a better, more effective mathematics student. | 4.76% | 9.52% | 42.86% | 38.10% | 4.76% |
---|---|---|---|---|---|
I would recommend these assistive technology devices to other students. | 9.52% | 9.52% | 33.33% | 42.86% | 4.76% |
I would like to continue using these devices. | 4.76% | 9.52% | 38.10% | 33.33% | 14.29% |

Table 5

Responses to Open-Ended Questions

<table>
<thead>
<tr>
<th>Describe what you like the most about the assistive technology devices?</th>
<th>Describe what you like the least about the assistive technology devices?</th>
<th>Additional Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>They helped me solve mathematical problems</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>It makes the understanding of math easier by using hands on activities.</td>
<td>Feels dragged out with some activities</td>
<td>None</td>
</tr>
<tr>
<td>There easier to use</td>
<td>Take too long</td>
<td>None</td>
</tr>
<tr>
<td>Hands on activities</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>It kept me occupied</td>
<td>Keep having to look up things</td>
<td>None</td>
</tr>
<tr>
<td>It gives you more of a visual for what were doing and people stay more focused and aren't disruptive.</td>
<td>The only thing I dislike is that sometimes I can't see the screen otherwise they're all good.</td>
<td>None</td>
</tr>
<tr>
<td>Origami Figures</td>
<td>Graphic Organizers</td>
<td>We should get no homework and class work; 80 minute breaks</td>
</tr>
<tr>
<td>For the most part I enjoyed having the graphic organizer.</td>
<td>Nothing really</td>
<td>I think if it is possible to have more things like this in the future.</td>
</tr>
</tbody>
</table>
I don't really care for them much because I don't use them much.

Using graphic organizers.

I don't like manipulating, it doesn't help me that much.

I don’t like anything about the assistive technology devices.

How we can use them to have a visual to what we are learning.

They make working with large numbers easy.

That it makes us understand the work easier.

Working with classmates.

I like the graphic organizer, it helps a lot.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I don’t really care for them much because I don’t use them much.</td>
<td>I don’t like doing the manipulations, it doesn’t help me that much.</td>
<td>Don’t like the assistive technology devices.</td>
</tr>
<tr>
<td>Using graphic organizers.</td>
<td>I don’t like the cutting out shapes or the graphic organizers.</td>
<td>Don’t like the assistive technology devices.</td>
</tr>
<tr>
<td>I don’t like anything about the assistive technology devices.</td>
<td>I don’t like doing the manipulations, it doesn’t help me that much.</td>
<td>Don’t like the assistive technology devices.</td>
</tr>
<tr>
<td>How we can use them to have a visual to what we are learning.</td>
<td>The setup time</td>
<td>Having three teachers is cool.</td>
</tr>
<tr>
<td>They make working with large numbers easy.</td>
<td>Their price</td>
<td>None</td>
</tr>
<tr>
<td>That it makes us understand the work easier.</td>
<td>Listening the whole class</td>
<td>None</td>
</tr>
<tr>
<td>Working with classmates</td>
<td>Listening the whole class</td>
<td>More partner work</td>
</tr>
<tr>
<td>I like the graphic organizer, it helps a lot.</td>
<td>Cutting out shapes</td>
<td>None</td>
</tr>
</tbody>
</table>

It can be interpreted from these quotations and the Likert scale that the students generally enjoyed using the graphic organizers and any group work was highly liked and appreciated. The students perceived that by using the graphic organizers they understood the content easier, were more focused, and there were less distracting behaviors. The students disliked cutting out shapes for manipulatives. Some students expressed apprehension during this particular class because they believed that the task of cutting out shapes was elementary. A few students expressed concern for the amount of time that was used in setting up the materials necessary for the assistive technology devices. In general the students would recommend assistive technology to their peers. They also enjoyed using the devices and would like to continue to use these and other devices. This positively

28
concerns with my research question; what are student perceptions of the ways in which assistive technology effects student learning and satisfaction in mathematics?

At the end of the unit the students took an assessment to evaluate the end results of the unit and the academic effectiveness of the use of the assistive technology. Again, taking the grades of all previous unit’s assessments and averaging them calculated the “Average Prior to Intervention.” The results were as follows:

Table 6

<table>
<thead>
<tr>
<th>Students with Disabilities</th>
<th>Test Average Post Intervention</th>
<th>Average Prior to Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>92%</td>
<td>64%</td>
</tr>
<tr>
<td>B</td>
<td>54%</td>
<td>58%</td>
</tr>
<tr>
<td>C</td>
<td>91%</td>
<td>51%</td>
</tr>
<tr>
<td>D</td>
<td>85%</td>
<td>63%</td>
</tr>
<tr>
<td>E</td>
<td>71%</td>
<td>60%</td>
</tr>
<tr>
<td>F</td>
<td>48%</td>
<td>57%</td>
</tr>
<tr>
<td>G</td>
<td>83%</td>
<td>45%</td>
</tr>
<tr>
<td>Average</td>
<td>75%</td>
<td>57%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Regular Education Students</th>
<th>Test Average Post Intervention</th>
<th>Average Prior to Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>98%</td>
<td>83%</td>
</tr>
<tr>
<td>I</td>
<td>23%</td>
<td>73%</td>
</tr>
<tr>
<td>J</td>
<td>103%</td>
<td>71%</td>
</tr>
<tr>
<td>K</td>
<td>71%</td>
<td>41%</td>
</tr>
<tr>
<td>L</td>
<td>46%</td>
<td>48%</td>
</tr>
<tr>
<td>M</td>
<td>88%</td>
<td>70%</td>
</tr>
<tr>
<td>N</td>
<td>78%</td>
<td>70%</td>
</tr>
<tr>
<td>O</td>
<td>103%</td>
<td>94%</td>
</tr>
<tr>
<td>P</td>
<td>78%</td>
<td>58%</td>
</tr>
<tr>
<td>Q</td>
<td>91%</td>
<td>61%</td>
</tr>
<tr>
<td>R</td>
<td>114%</td>
<td>77%</td>
</tr>
<tr>
<td>Average</td>
<td>81%</td>
<td>68%</td>
</tr>
</tbody>
</table>
It can be seen, in the assessment grades of the students, overall, there was a positive correlation between the grades prior to the use of assistive technologies and after their use. This coefficient was calculated to be 0.39893384. It is also shown by using a t-Test, Paired Two Sample for Means, that this is significant with a p-value of 0.004438.

Teachers were interviewed as to their perceptions of the effectiveness of using assistive technology within their mathematics classroom. I interviewed the teachers in two ways: semi-structured interviews and more informal conversations before and after classroom observations. The semi-structured interviews were conducted at the
beginning and end of the study. The first interview (supplied in Appendix C) focused on the teacher's background, teaching experience, goals in using assistive technology, and knowledge of individual students. The following is the information that was collected during the interview process:

Table 8

<table>
<thead>
<tr>
<th>First Interview</th>
<th>Special Education Teacher</th>
<th>Mathematics Teacher</th>
<th>Teacher's Assistant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background</strong></td>
<td>Special Education teacher for 12 years; Certification K-12 in Special Education</td>
<td>Master's Degree in Liberal Arts with a concentration in Technology; Certification Mathematics 7-12</td>
<td>Teacher's Assistant for 1 year; Certification 5-12 Mathematics and 7-12 Special Education: Mathematics, Currently completing Masters Program</td>
</tr>
<tr>
<td><strong>Teaching Experiences</strong></td>
<td>Taught at intermediate level and high school, taught self-contained to co-teaching</td>
<td>Taught six years in senior high school</td>
<td>No permanent fulltime teaching experience</td>
</tr>
<tr>
<td><strong>Goals for using Assistive Technology</strong></td>
<td>&quot;I try to incorporate useful software and websites as much as possible.&quot;</td>
<td>&quot;Give the students all opportunities to succeed.&quot;</td>
<td>&quot;I would like to give my students every advantage to be successful.&quot;</td>
</tr>
<tr>
<td><strong>Class Composition</strong></td>
<td>Variety of classes, with differing learning styles and needs</td>
<td>One inclusion class and four general education classes with a co-teacher</td>
<td>&quot;In my job description I am here to assist the students therefore I am in a variety of classes, differing in abilities and subjects.&quot;</td>
</tr>
</tbody>
</table>

The final interview (see Appendix D) highlighted the teacher's thoughts regarding the impact of assistive technology on students. More informal conversations were relatively brief. Verbal responses were recorded and synthesized.
into the qualitative portion of the results. My answers as the Teacher’s Assistant and researcher were omitted due to bias on my part.

Table 9

<table>
<thead>
<tr>
<th>Second Interview</th>
<th>Special Education Teacher</th>
<th>Mathematics Teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did the students’ performance change?</td>
<td>“These devices help to focus them in on tasks so that there is less confusion and extraneous information.”</td>
<td>“Yes. The students were able to visualize the concepts better therefore they understood the material better.”</td>
</tr>
<tr>
<td>Change the students’ communication level?</td>
<td>“It allows students to communicate clearly through different modes, so that I can assess learning rates and needs.”</td>
<td>“Yes. The students were able to understand the terminology better.”</td>
</tr>
<tr>
<td>Indications of enjoyment of devices?</td>
<td>“This depends on their skill and comfort level.”</td>
<td>“They were getting answers, correctly. The students competed for the correct answers.”</td>
</tr>
<tr>
<td>Advantages of using the devices?</td>
<td>“Provide ways around learning barriers.”</td>
<td>“Visualization of the concepts. The information was given as a whole not bits and pieces, they saw the whole picture.”</td>
</tr>
<tr>
<td>Disadvantages of using the devices?</td>
<td>“It takes time and training for the student and teacher to use some devices effectively.”</td>
<td>“More time and training is needed for the different devices. Also making sure the technology works correctly. Transition to a different teaching style.”</td>
</tr>
<tr>
<td>In what activity will the devices be useful?</td>
<td>“They will be useful to record information and get around getting stuck on just data correction and calculation.”</td>
<td>“Any topic or unit. In basic geometry, with triangles and such. Transformations.”</td>
</tr>
<tr>
<td>Barriers?</td>
<td>“Mostly time and training.”</td>
<td>“Same as disadvantages.”</td>
</tr>
<tr>
<td>Frustrations of the students?</td>
<td>“Initial use and training when they are unfamiliar.”</td>
<td>“Knowledge of the devices and types of materials.”</td>
</tr>
<tr>
<td>Were the devices appropriate?</td>
<td>“They were appropriate. They allowed students to focus on the important steps of the activity.”</td>
<td>“Yes they were appropriate.”</td>
</tr>
<tr>
<td>Unnecessary barriers?</td>
<td>“It really depends on what technology is being used with what student.”</td>
<td>“Not that was seen.”</td>
</tr>
</tbody>
</table>
The data collected shows that the teachers believed the use of assistive technology in the secondary inclusion classroom had a positive effect on the students. Within the informal conversations the teachers expressed interest in expanding their knowledge base of the types of assistive technologies that can be used in their classrooms. The special education teacher enjoyed the increase of self confidence that the students experienced. The mathematics teacher focused on the increased amount of understanding by the students. It can be concluded that the participating teachers were satisfied with the results.

To triangulate my data I also conducted daily field note observations, this data is as follows:

- **Day One – Properties of Geometric Solids**
  - Students were defiant and unresponsive to the activity. Many students were off task and believed that the activity was below them. A few students expressed that the activity was "boring." Some students did not pay attention or slept.
  - One student was quoted as saying, "I am not in second grade I shouldn’t have to do this s**t."

- **Day Two – Venn Diagrams and Vocabulary**
  - Students were once again off task and uncooperative. One student decided that he didn’t want to participate at all and was asked by the teacher to go to the office. This was time consuming for the entire
class because the lesson had to stop for 5-10 minutes to deal with one student.

- Some students knew the different vocabulary. These students took time to explain to the students that didn’t have a good understanding the differences and similarities of the terms.

- Day Three – Surface Area

  - Students enjoyed looking at the origami figures to get a better understanding of surface area. One student approached the teacher after class for extra help because she could not understand or concentrate in the classroom environment.

  - One student was confused as to the way in which surface area was calculated, the teacher took time to take apart their origami figure and show the student all the sides that are calculated into the surface area. The student had an “Ah ha” moment.

- Day Four – Volume

  - Students were familiar with some of the volume formulas from previous courses. Volume was presented to the students as area multiplied by the height of the figures. The students seemed to have a good understanding with this concept.

  - One student described the volume of a rectangular prism as a bunch of pizza boxes stacked on top of one another.

- Day Five – Characteristics Review
• Originally this was to be the only review day. However after this review session it was understood by all the teachers that the students were not ready to take an exam at this point.

• In a smaller class setting this unit might have been successful, however with the diverse needs of the students and the behavioral issues, the students needed a longer review time to better understand the material.

• The students made the concentration game into a competition in which they became increasingly interested in getting the correct answer and understanding the reasoning behind the question and answers.

• Day Six – Surface Area Review
  
  • Students worked independently on questions relating to surface area. We then reviewed the answers and fielded all questions.

  • One student did not understand how a question was answered so another student came up to the overhead and explained the reasoning in a manner different than the teachers.

• Day Seven – Volume Review
  
  • Students worked independently on questions relating to volume. We then reviewed the answers and fielded all questions.

  • On student thanked the teachers after this additional review session because she “finally understood it.”
• Day Eight – Overall Review
  • Students worked in groups and individually on questions that were similar to the questions that would be on the exam.
  • The students worked well together and made sure each other understood the reasoning behind the answers as well as the correct answer.

• Day Nine – Unit Exam
  • Students were cooperative and took the test quietly.

As it can be shown from the field notes, student behavior was an issue in this particular classroom. However the students showed that they could work cooperatively and on the final day of the intervention that they could be successful given the proper support.

CONCLUSION

The importance of proficiency in mathematics, especially for students with disabilities, cannot be overstated. Researchers have used a variety of strategies to use technology in ways that enhance students' skills and knowledge in mathematics. As is often the case with technology, advances in the marketplace provide a rich array of possibilities for educators to explore. Recent applications of assistive technology in math for students with disabilities have explored:

• Adaptive calculators
• Drill and practice via the web
• Problem solving via the web
- Spreadsheets for calculating and problem solving
- Software tools for visualizing data
- Virtual manipulatives
- Applications of universally design software in math

The results of this study consistently showed that students who worked with assistive technology devices had a stronger grasp of the conceptual foundations for geometric solids, surface area, and volume than they previously did with units that did not implement the use of assistive technologies. This is based on their performance, self-evaluations, teacher evaluations, field notes, and academic assessment results. I have shown that assistive technology is effective in the inclusive, secondary mathematics classroom for all students. Both the special education and regular education mathematics teachers in the classroom corroborated this. They, as well as I, perceived that assistive technology facilitated learning. Students believed that the devices helped them understand the concepts easier and kept them more focused. Teachers understood that assistive technology gave the students “a way around learning barriers” (Westcott, 2008).

Enabling persons with disabilities to take full advantage of assistive technologies is imperative for their success in home, school, and community settings. It is critical that appropriate technology be available so that persons with disabilities are not denied the full benefit of educational programs.
IMPLICATIONS FOR RECOMMENDATIONS FOR FURTHER RESEARCH

While the research and academic knowledge base which informs current instructional practice concerning students with disabilities and math is considerable, much more work needs to be undertaken to determine the kinds of assistive technology that enhance math performance. It is imperative that we correlate the type of assistive technology with the curriculum as well as with the disability of the student to give that student a better chance of success. Distinguishing itself to other academic applications of assistive technology, the field of math appears to offer considerable measurement tools and procedures that will permit professionals to make statements about performance outcomes in math. Taken as a whole, educators must consider that those with learning disabilities may be lacking perception, understanding, and processing abilities, and special care should be taken in selecting teaching and learning strategies for them.

Interest in the assessment of assistive technology outcomes is a relatively recent phenomenon. While there is extensive research on measuring mathematics abilities of children, there is little in the literature regarding assistive technologies that enhance mathematical performance and achievement. While technology can facilitate access and participation, we must look seriously at issues of challenge and engagement. Further, we may need to rethink assistive technology service delivery systems to consider how performance support tools might be provided to everyone.
REFERENCES


APPENDIX
Appendix A

CITI Collaborative Institutional Training Initiative

Human Research Curriculum Completion Report
Printed on Wednesday, July 9, 2008

Learner: Krystal Barber (username: [Redacted])
Institution: SUNY - College at Brockport

Contact Information
Department: Education
Phone: [Redacted]
Email: [Redacted]

Group 2: This Group is appropriate for faculty, staff, graduate students and undergraduate students completing thesis or independent study projects. In addition to the required modules, complete any of the following modules applicable to your research; research with prisoners, research with children, research in public and elementary schools, international research, internet research.

Questions? Send an email to the institutional coordinator at cdonalds@brockport.edu

Stage 1. Basic Course Passed on 07/09/08 (Ref # 1940895)

<table>
<thead>
<tr>
<th>Required Modules</th>
<th>Date Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>07/09/08</td>
</tr>
<tr>
<td>History and Ethical Principles - SBR</td>
<td>07/09/08</td>
</tr>
<tr>
<td>Defining Research with Human Subjects - SBR</td>
<td>07/09/08</td>
</tr>
<tr>
<td>The Regulations and The Social and Behavioral Sciences - SBR</td>
<td>07/09/08</td>
</tr>
<tr>
<td>Assessing Risk in Social and Behavioral Sciences - SBR</td>
<td>07/09/08</td>
</tr>
<tr>
<td>Informed Consent - SBR</td>
<td>07/09/08</td>
</tr>
<tr>
<td>Privacy and Confidentiality - SBR</td>
<td>07/09/08</td>
</tr>
<tr>
<td>SUNY College at Brockport</td>
<td>07/09/08</td>
</tr>
</tbody>
</table>

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI participating institution. Falsified information and unauthorized use of the CITI course site is unethical, and may be considered scientific misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Course Coordinator
Student Questionnaire:

1. I enjoyed using the assistive technology devices.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

2. I feel more satisfied in my mathematical abilities after using the assistive technology devices.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

3. Assistive technology devices help me communicate.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<td>1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
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</table>

4. Assistive technology devices help me in mathematics.

<table>
<thead>
<tr>
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<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
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</table>

5. I believe that the assistive technology devices make me a better, more effective mathematics student.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
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<td>1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
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</table>

6. I would recommend these assistive technology devices to other students.

<table>
<thead>
<tr>
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<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
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<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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</tbody>
</table>

7. I would like to continue using these devices.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
8. Describe what you like the most about the assistive technology devices?

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

9. Describe what you like the least about the assistive technology devices?

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

10. Additional Comments

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
Appendix C

Teacher’s First Interview:
1. What is your background (i.e. certification, education, personal experiences)?

2. Explain your teaching experiences.

3. What are your goals in using assistive technology in your classroom?

4. Explain the composition of your class (i.e. learning styles, student needs, student disabilities).
Appendix D

Teacher's Second Interview:

1. How does the students' performance change when using assistive technology devices?

2. How does assistive technology change the students' communication level?

3. What are the indications that the students give to display if they enjoy using the assistive technology devices? (i.e. do the students reach for the devices when they want it?)

4. What are the advantages of using the devices? What are the disadvantages for these assistive technology devices?
<table>
<thead>
<tr>
<th>Name</th>
<th>Sketch</th>
<th>Description/Definition</th>
<th>Characteristics</th>
</tr>
</thead>
</table>

Name: ____________________________
Date: ____________________________
5. In what functional activity/routine/task will the devices be useful? Does their use enhance support to complete the activity or does their use prevent students from doing the activity?

6. What are the barriers to using the devices (training, support, time, attitudes, ability)?

7. What frustrations, if any, do students experience and if so, at what point when using the devices?

8. How are the assistive technology devices chosen for the lesson appropriate or inappropriate for the task?
<table>
<thead>
<tr>
<th>Name</th>
<th>Rectangular Prism</th>
<th>Cube</th>
<th>Pyramid</th>
<th>Cone</th>
<th>Cylinder</th>
<th>Sphere</th>
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</tr>
<tr>
<td>Description/Definition</td>
<td>A three-dimensional figure that has congruent polygons as bases in parallel planes and whose sides are parallelograms.</td>
<td>A three-dimensional figure with six faces, all of which are congruent squares.</td>
<td>A three-dimensional figure with a single base and sides that are triangles.</td>
<td>A three-dimensional figure whose base is a circle and all segments that join the circle to a vertex not in the plane of the circle.</td>
<td>A three-dimensional figure that has two circles as bases and segments of parallel lines joining the curves.</td>
<td>A surface where all points lie equal distance from a fixed point in space.</td>
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<td>- 4 Triangular Faces</td>
<td>- 1 Circular Face</td>
<td>- 1 Rectangular Face</td>
<td>- 1 Face</td>
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<td>- Real Life: Box</td>
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<td>- 8 Edges</td>
<td>- 1 Edge</td>
<td>- Real Life: Pop Can</td>
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<td>- Real Life: Louve</td>
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</table>
9. What kind of barriers, if any, does the assistive technology present in a given environment? Does it create an unnecessary barrier?
Appendix F

Cube
Rectangular Prism
Pyramid
Cylinder
Cone
version 1
Vocabulary

Altitude
The ________ with one endpoint at the ________ and the other in the plane that contains the ________.

Base
The closed ________ that is parallel to the horizon.

Circular Cone
A cone whose base is a ________.

Circular Cylinder
A cylinder whose base is a ________.

Cone
A three-dimensional figure whose base is a ________ and all segments that join the circle to a ________ not in the plane of the circle.

Cube
A three-dimensional figure with six faces, all of which are congruent ________.

Cylinder
A three-dimensional that has two circles as ________ and segments of ________ ________ joining the curves.

Edge
The intersection of two ________ in a polyhedron.

Face
A ________ in a polyhedron.

Geometric Solid
A region in space bounded by a closed surface.

Polyhedron
A solid figure with many ________.

Prism
A three dimensional figure that has congruent polygons as ________ in ________ plans and whose sides are ________ ________.

Pyramid
A three dimensional figure with a single ________ and sides that are ________ ________.

Radius of a Sphere
A segment with one endpoint at the ________ of a sphere and the other endpoint on the sphere.

A pyramid whose base is a regular polygon and whose altitude intersects the plane of its ________ at the ________ ________ of the base.

Sphere
A surface where all points lie ________ ________ from a fixed point in space.

Vertex
Any point on a polyhedron that is the ________ ________ of ________ or more faces.
Vocabulary

Altitude
The segment with one endpoint at the vertex and the other in the plane that contains the base.

Base
The closed polygon that is parallel to the horizon.

Circular Cone
A cone whose base is a circle.

Circular Cylinder
A cylinder whose base is a circle.

Cone
A three-dimensional figure whose base is a circle and all segments that join the circle to a vertex not in the plane of the circle.

Cube
A three-dimensional figure with six faces, all of which are congruent squares.

Cylinder
A three-dimensional that has two circles as bases and segments of parallel lines joining the curves.

Edge
The intersection of two polygons in a polyhedron.

Face
A polygon in a polyhedron.

Geometric Solid
A region in space bounded by a closed surface.

Polyhedron
A solid figure with many faces.

Prism
A three dimensional figure that has congruent polygons as bases in parallel planes and whose sides are parallelograms.

Pyramid
A three dimensional figure with a single base and sides that are triangles.

Radius of a Sphere
A segment with one endpoint at the center of a sphere and the other endpoint on the sphere.

Regular Pyramid
A pyramid whose base is a regular polygon and whose altitude intersects the plane of its base at the center of the base.

Sphere
A surface where all points lie equal distance from a fixed point in space.

Vertex
Any point on a polyhedron that is the intersection of three or more faces.
Venn Diagrams
Geometric Solids

Rectangular Prism  Pyramid

Cone  Cylinder

Cone  Pyramid

Cube  Sphere
Venn Diagrams
Geometric Solids

Rectangular Prism
- 6 Faces
- Rectangular Faces
- 8 Vertices
- 12 Edges

Pyramid
- 5 Faces
- 4 Triangular Faces
- 1 Square Face
- 5 Vertices
- 8 Edges

- One-Third the Volume of a Rectangular Prism

Cone
- 2 Faces
- 1 Semi-Circle Face
- 1 Circular Face
- 1 Vertex
- 1 Edge

Cylinder
- 3 Faces
- 1 Rectangular Face
- 2 Circular Faces
- No Vertices
- 2 Edges

Cone
- 2 Faces
- 1 Semi-Circle Face
- 1 Circular Face
- 1 Vertex
- 1 Edge

Pyramid
- 5 Faces
- 4 Triangular Faces
- 1 Square Face
- 5 Vertices
- 8 Edges

Cube
- 6 Faces
- Square Faces
- 8 Vertices
- 12 Edges

- 3D Geometric Figure

Sphere
- 1 Face
- No Vertices
- No Edges
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<th>Equation</th>
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### Surface Area

#### Geometric Solids

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<td>Equation</td>
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Volume

Name: _______________________
Date: _______________________
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<th>Name</th>
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<td><img src="image12" alt="Stacked Cubes" /></td>
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</table>
Cube

Surface Area: $6s^2$
Volume: $s^3$

Rectangular Prism

Surface Area: $2lw + 2wh + 2hl$
Volume: $lwh$

Pyramid

Surface Area: $2sl + s^2$
Volume: $\frac{1}{3}s^2h$

Sphere

Surface Area: $4\pi r^2$
Volume: $\frac{4}{3}\pi r^3$

Cylinder

Surface Area: $2\pi r^2 + 2\pi rh$
Volume: $\pi r^2h$

Cone

Surface Area: $\pi rl + \pi r^2$
Volume: $\frac{1}{3}\pi r^2h$
<p>| <strong>Altitude</strong> | The segment with one endpoint at the vertex and the other in the plane that contains the base. |
| <strong>Base</strong> | The closed polygon that is parallel to the horizon. |
| <strong>Circular Cone</strong> | A cone whose base is a circle. |
| <strong>Circular Cylinder</strong> | A cylinder whose base is a circle. |
| <strong>Cone</strong> | A three-dimensional figure whose base is a circle and all segments that join the circle to a vertex not in the plane of the circle. |
| <strong>Cube</strong> | A three-dimensional figure with six faces, all of which are congruent squares. |
| <strong>Cylinder</strong> | A three-dimensional that has two circles as bases and segments of parallel lines joining the curves. |
| <strong>Edge</strong> | The intersection of two polygons in a polyhedron. |
| <strong>Face</strong> | A polygon in a polyhedron. |</p>
<table>
<thead>
<tr>
<th>Geometric Solid</th>
<th>A region in space bounded by a closed surface.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyhedron</td>
<td>A solid figure with many faces</td>
</tr>
<tr>
<td>Prism</td>
<td>A three dimensional figure that has congruent polygons as bases in parallel planes and whose sides are parallelograms.</td>
</tr>
<tr>
<td>Pyramid</td>
<td>A three dimensional figure with a single base and sides that are triangles.</td>
</tr>
<tr>
<td>Radius of a Sphere</td>
<td>A segment with one endpoint at the center of a sphere and the other endpoint on the sphere.</td>
</tr>
<tr>
<td>Regular Pyramid</td>
<td>A pyramid whose base is a regular polygon and whose altitude intersects the plane of its base at the center of the base.</td>
</tr>
<tr>
<td>Sphere</td>
<td>A surface where all points lie equal distance from a fixed point in space.</td>
</tr>
<tr>
<td>Vertex</td>
<td>Any point on a polyhedron that is the intersection of three or more faces.</td>
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</table>
1. Find the surface area of a wooden box whose shape is of a cube, and if the edge of the box is 62 cm.

2. The diameter of iron sphere is 4 cm. It is beaten and drawn into a wire of length 1.4 cm. Find the radius of the wire.

3. 150 metal spheres of radius 3 m each melted and this melted solution is filled in rectangular prism with base area 14 m × 20 m. Find the height of rectangular prism filled with solution.

4. What is the volume of a regular cylinder whose base has radius of 15 cm and has height of 22 mm?

5. Some contaminated soil covers an area of 160 sq yd. Andrews must remove the top 25 inches of soil in this area. If each truck can haul 10 cubic yards of soil, how many full truckloads of contaminated soil will Andrews be removing?

6. Soda is sold in aluminum cans that measure 15 inches in height and 6 inches in diameter. How many cubic inches of soda are contained in a full can?

7. A cubical box has dimensions 7 in × 24 in × 60 in. How many cubes dimension 5 in × 5 in × 5 in can be fixed in cubical box?

8. The diameter of iron sphere is 8 cm. It is beaten and drawn into a wire of diameter 1.6 cm. Find the length of the wire.

9. A company manufactures large dice for children's games. The dice are cubes with one side measuring 1.2 inch in length. The dice are formed when a liquid plastic is poured into a mold of the die. The company uses trays that contain one dozen die molds in each tray. If the liquid plastic is measured in cubic inches, how much liquid plastic is needed to fill one tray?

10. A cylindrical glass is 28 cm deep and 6 cm wide. How much liquid can the glass hold?
Part I:

For number 1-3 tell whether the statement is true or false. If false, then change the statement to make it true. Write the correct answer on the line to the left.

1. The formula for the volume of a sphere is \( \frac{4}{3} \pi r^3 \).
   
   \[ \text{True} \]

2. The bases of a cylinder are congruent.
   
   \[ \text{False} \]

3. Lateral faces of a regular pyramid are congruent right triangles.
   
   \[ \text{False} \]

Part II:

Write the best answer on the line to the left:

4. Given the following figure: What is the altitude of the regular pyramid?
   
   a. 3
   b. 4
   c. 5
   d. 6
   
   \[ \text{b. 4} \]

5. The surface area of a cylinder is
   
   a. \( 2\pi r^2 + 2\pi hr \)
   b. \( 2\pi r^2 \)
   c. \( \frac{2\pi r^2}{h} \)
   d. \( 2\pi r^2 - 2\pi hr \)
   
   \[ \text{a. } 2\pi r^2 + 2\pi hr \]

6. Given the following, what is the diameter of the circle?
   
   a. 1.5
   b. 3
   c. \( \pi \)
   d. 6
   
   \[ \text{b. 3} \]
7. A triangular pyramid has a square base with each side of length 10 and a height of 4. What is the volume of this triangular pyramid?
   a. 100
   b. $133 \frac{1}{3}$
   c. $266 \frac{1}{6}$
   d. 400

8. Find the surface area of the cone to the right. The area is
   a. $24\pi$ cm
   b. $48\pi$ cm
   c. $96\pi$ cm
   d. $480\pi$ cm

9. Find the volume of the cone to the right. The volume is
   a. $32\pi$ cm$^3$
   b. $48\pi$ cm$^3$
   c. $96\pi$ cm$^3$
   d. $288\pi$ cm$^3$

10. When a sphere is intersected by a plane a(n) _______ is created.
    a. circle
    b. line
    c. square
    d. ellipse

Part III:
Solve 11-16, write the answer on the line to the left. Remember to label your units correctly:

11. The volume of a cone is 261 cubic inches. What is the volume of a right circular cylinder of the same height and with the same radius of the base?

12. An open box will be made from a piece of cardboard 30 inches wide by 36 inches long by folding congruent square tabs at each corner. If 3-inch squares are cut at each corner and the sides are folded up, what is the volume in cubic feet of the box?
13. Find the total surface area and volume of the rectangular prism. The length of each side of the square base of the rectangular prism is 7 centimeters and its height is 13 centimeters.

14. The volume of a cube is equal to the volume of a rectangular solid that has a length of 20 inches, a width of 5 inches, and a height of 10 inches. Find the perimeter of one face of the cube.

15. A cardboard box has length $x - 2$, width $x + 1$, and height $2x$.
   a. Write an expression, in terms of $x$, to represent the volume of the box.
   b. If $x = 8$ centimeters, what is the number of cubic centimeters in the volume of the box?

16. A storage container in the shape of a right circular cylinder is shown in the accompanying diagram. What is the volume of this container, to the nearest hundredth?
Part IV:
Solve 17-22, write the answer on the line to the left. Remember to label your units correctly:

17. Denise is designing a storage box in the shape of a cube. Each side of the box has a length of 10 inches. She needs more room and decides to construct a larger box in the shape of a cube with a volume of 2,000 cubic inches. By how many inches, to the nearest tenth, should she increase the length of each side of the original box?

18. The side of the base of a square pyramid is 5 feet and the pyramid has a slant height of 8 feet. The pyramid is to be completely covered in gold foil and the foil comes in rolls each containing 10 square feet of foil. What is the minimum number of rolls needed to cover the pyramid?
19. A small, open-top packing box, similar to a shoebox without a lid, is three times as long as it is wide, and half as high as it is long. Each square inch of the bottom of the box costs $0.008 to produce, while each square inch of any side costs $0.003 to produce. Write a function for the cost of the box described above. Using this function, determine the dimensions of a box that would cost $0.69 to produce.

20. A rectangular piece of cardboard is to be formed into an uncovered box. The piece of cardboard is 2 centimeters longer than it is wide. A square that measures 3 centimeters on a side is cut from each corner. When the sides are turned up to form the box, its volume is 765 cubic centimeters. Find the dimensions, in centimeters, of the original piece of cardboard. (Round your answers to the nearest tenth)
21. Proficient Construction Company is building a new office space. The exterior of the building is not quite complete. The roofing is going to cost $2.50 per square foot, the siding is $1.75 per square foot, and the flooring is $3.25 per square foot. Given the dimensions on the diagram how much will the building cost to finish?

22. Joey wants to serve ice cream at his birthday party. He would like to serve the most ice cream as possible to each guest in one cone. In order to serve the most ice cream he needs to decide whether to use a sugar ice cream cone or a cake cone. Using the diagrams to the right determine algebraically which ice cream cone would give the guests the maximum amount of ice cream in the cone (to the rim of the cone only).